DOCUMENT RESUME

ED 167 184 IR 007 104

AUTHOR	Andrews, Gordon C., Ed.; Knapper, Christopher K., Ed.
TITLE	Computerized Multi-Media Instructional Television. COMIT. Proceedings of a Symposium.
INSTITUTION	Waterloo Univ. (Ontario).
PUB DATE	6 Apr 78
NOTE	119p.; Proceedings of a Symposium on COMIT (Waterloo, Ontario, Canada, April 6, 1978); For related documents see IR 007 186-193 and IR 007 285
EDRS PRICE	MF-$0.83 HC-$6.01 Plus Postage.
DESCRIPTORS	Audiovisual Aids; *Computer Assisted Instruction; *Educational Strategies; Educational Television; Formative Evaluation; *Higher Education; Individualized Instruction; *Instructional Aids; *Instructional Design; Learning Modules; Program Evaluation
IDENTIFIERS	*Computerized Multimedia Instructional Television

ABSTRACT

A joint research project in educational techniques, which was conducted by the University of Waterloo and the IBM Corporation, explored the use of color television with random-access videotape under computer control. At the end of the three-year project, papers were solicited from all COMIT (Computerized Multi-Media Instructional Television) participants, and 12 of the 15 professors who had authored courses submitted papers. A representative sample of seven papers was presented at a one-day COMIT Symposium, some accompanied by videotaped demonstrations that illustrated the teaching techniques used. In order to provide as complete a record of the project as possible, all 12 of the papers from participants are included in this volume (grouped, where possible, by subject), as well as comments by the project director and the coordinator from IBM and a summary of the pedagogical lessons learned from COMIT. Courses described include environmental engineering, survey design, advanced calculus, organic synthesis, biology, human movement, ice hockey practice, football, leisure experience, history of art, and English. The appendix contains the schedule for the COMIT Symposium with the names of the speakers. (Author/JEG)

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PROCEEDINGS OF A SYMPOSIUM ON

COMIT

COMPUTERIZED MULTI-MEDIA INSTRUCTIONAL TELEVISION

THURSDAY, 6 APRIL, 1978

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Symposium Editors:

Gordon C. Andrews
Chairman, Computers in Education Committee

Christopher K. Knapper
Teaching Resource Person

UNIVERSITY OF WATERLOO, WATERLOO, ONTARIO N2L-3G1, CANADA

PREFACE

In September 1974, the IBM Corporation approached the University of Waterloo with a proposal for a joint research project in educational techniques which would explore, in particular, the use of colour television with random - access video-tape under computer control. The proposal was referred by Dr. T.A. Brzustowski, Vice-President (Academic), to the Computers in Education Committee (CEC) for evaluation and comments. After some negotiation between UW and IBM, the project began officially in January 1975 with the name COMIT (for Computerized Multi-media Instructional Television), with Dr. J.B. Moore, Associate Professor of Management Science, as COMIT Project Director and with E.O. Elkeer representing IBM.

The Computers in Education Committee maintained an informal contact with COMIT during its three years of operation and, as the termination date (15 April 1978) approached, members of the Committee volunteered to assist in disseminating the knowledge obtained from the project. An editorial sub-committee was appointed and papers were solicited from all COMIT participants. Twelve of the fifteen professors who had participated in COMIT as "course authors" submitted papers and a representative sample of seven papers was selected for presentation at a one-day COMIT Symposium held on Thursday, 6 April, 1978. Some of the Symposium presentations were accompanied by video-taped demonstrations that illustrated, effectively, the teaching techniques used.

In reviewing the submitted papers for publication in this volume, the editors felt an obligation to produce as complete a record of the project as possible, while maintaining an acceptable standard of content and format. Not all of the papers submitted conformed to the specifications in the Call for Papers and, in some cases where it was not feasible to return papers to their authors for revision, the editors arranged for re-typing and made some minor modifications and condensations. The resulting volume is believed to be a fairly complete record of the COMIT Project as described by the participants. This volume should not, however, be mistaken for the formal report of the project which will be prepared by the COMIT Project Director and readers who want more information should contact the Director.

The papers which follow are arranged in a rather arbitrary order. The comments of the Director and the IBM Coordinator are first, followed by the papers from twelve of the course authors (grouped, where possible, by subject), followed by a concluding paper by Dr. C.K. Knapper, the University of Waterloo's Teaching Resource Person, summarizing the pedagogical lessons learned from COMIT. The appendix contains the schedule for the COMIT Symposium, showing the Symposium speakers.

Gordon C. Andrews
Christopher K. Knapper

6 July, 1978

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AN OVERVIEW OF THE COMIT PROJECT

by

John B. Moore

Associate Professor of Management Science

COMIT Project Director

University of Waterloo

Abstract: This communication describes the prime objectives of the COMIT research project, highlights the major accomplishments, and provides a subjective evaluation of the benefits and costs of multi-media computer-aided-instruction.

Introduction:

The acronym COMIT, standing for Computerized Multi-media Instructional Television, was chosen to identify a major research project in computer-assisted learning (CAL) which was undertaken jointly by the University of Waterloo and IBM at the University of Waterloo. The project began in January 1975 and the research was completed in March 1978.

The main goal of the research was to integrate the educational technologies of television and CAL into a single delivery system. The objective was to determine whether the combined technologies would result in a learning vehicle which would have significant advantages over either educational television or conventional CAL.

The responsibility of IBM was to develop the unique hardware interfaces and software, that of the University to provide the application (courseware) to be used in the experiments.

It was decided at the outset to include as many audio-visual functions in the experimental system as was reasonably possible, subject to the requirements that the audio-visual hardware components should be commercially available and that existing CAL authoring languages should be used. (The languages necessarily were augmented with commands to control the audio-visual devices.) The following functional components were selected and synthesized into a working terminal system:

- a standard SONY colour television receiver
- a standard 3270 keyboard with upper/lower APL character set and a 5th programmable character set
- a sonic pen with a dismountable pickup which provided a 220 by 330 grid of addressable (detectable) points on the screen surface and capability for off-screen detects
- a facsimile printer for obtaining hard copy output of screen displays
- direct access to video tape segments
- direct access to audio tape segments
- direct access to a video disk which could store 550 35mm slides
- colour graphics under pen, keyboard or program control.

All video output appeared on the television screen and audio output was presented through earphones.

The system consisted of four terminals with the above capabilities connected to a System 7 minicomputer which in turn was channel-connected to the University's System/370 Model 158. The courseware was resident in the 158 and the System 7-158 protocol was similar to that used for a 3270 control unit. The System 7 controlled all the audio-visual library devices and generated and stored the colour graphics.

Two major programming languages were used for authoring: a modified version of IIS and an enhanced form of APL.

The Experiments:

Initially, thirty professors were contacted and given the opportunity to participate voluntarily in the project. From this group fifteen authors became involved and entered the process of topic selection, construction of learning objectives, detailed presentation design, and implementation. The content in most cases covered approximately three to four hours of lecture material. The selection of the pedagogy (drill and practice, tutorial, simulation, information retrieval, etc.) was left to the author. Each author (professor) worked closely with one of the project analysts and coding was done by twelve students hired on a full-time basis. The subject matter varied immensely. Subject areas included biology, English, poetry, water pollution, calculus, football, statistics, volleyball, organic chemistry, geography, leisure studies, theory of interest, accounting, hockey, biomechanics, and fine arts. Approximately half used a tutorial presentation; the others were mixtures of simulation, drill and practice and information retrieval. The resulting models took students anywhere from one hour to nine hours to complete. Over 570 students participated in the experiments and this usage involved upwards of 2000 hours of terminal time spread over 15 months.

Evaluation:

In four experiments, the class was divided into two groups - a control group was taught the material in the usual lecture fashion - and an experimental group took the same material using the COMIT system. In the other experiments, either the whole class (or team in the case of the volleyball, football and hockey modules) or a selected subset of the class used the research system. Six of the experiments were run more than once.

Results:

The University had three questions to which it was hoped the research would provide the answers:

First - Do students learn better with multi-media CAL? In all four experiments where direct comparisons were made, the students using the system had slightly higher average scores on post-tests than the students in the lecture group. The differences in each case were not statistically significant. No rigorous attempt was made to measure changes in affective behaviour of the COMIT students. However, a questionnaire given to students after completing the computer session showed generally positive attitudes to this form of learning.

Second - Can resources be saved using a multi-media terminal? The pre-project conjecture was that the richness of the terminal environment would allow realistic simulations of laboratory experiments to be conducted, thus providing potential savings in lab equipment. No firm conclusion was reached because no well-controlled experiments were done.

Nonetheless, students participated willingly in the laboratory simulations, and the information retrieval program used with the art history slides had a high utility. In three instances (theory of interest, history of leisure and statistics) significant amounts of professor time were saved once the respective modules were operational. Against the potential savings must be weighed the increased costs required for computer and audio-visual specialists, computer time and author development time.

Third - What is the potential of multi-media CAL for extramural education? It is in this area that perhaps the greatest potential benefits lie. With the advent of microcomputers, low cost terminals, video disks and cheap mass storage, the use of multi-media CAL becomes definitely feasible for home education, correspondence programs, remedial learning and special education. Such uses make it possible to spread the high capital cost of courseware development over many independent users. Without such uses the problem of justifying a multi-media CAL system for in-house use only is much more difficult.

Some Lessons Learned:

In terms of ability to enhance conventional CAL with multi-media attributes, the following list is arranged in order of decreasing priority of function: graphics, colour, slides, tapes (audio and video). This ranking represents a consensus of the views of the project personnel. Experience taught us also that good response time was vital for modules in which all student input was done with the pen. Pen resolution and calibration is extremely important when two or more detectable areas are close together. Also, production of audio-visual materials was and is a very time-consuming process relative to coding. In some instances we chose to omit a potentially valuable tape segment because of the production factors involved.

Conclusions:

The COMIT project must be considered an overall success in that almost without exception, the original objectives of the research were achieved. Aside from the observations made previously, the truth of the following three statements was substantiated by the experiences in the project:

1. CAL can use multi-media effectively but it is not essential for good CAL.
2. Good CAL requires a team effort. The author is the most important team member.
3. Technology is not the limiting factor in CAL development.

The papers which follow provide the individual viewpoints of most of the fifteen participating professors. They are well worth reading.

COMIT: EXPERIENCES AND OBSERVATIONS

by

Eileen O. Elkeer
Advisory Education Representative
IBM COMIT Project Coordinator
IBM Canada Limited

Abstract: This paper was prepared from the activities of a Joint Study undertaken by IBM Canada Limited and the University of Waterloo. The study was given the Acronym COMIT (for Computerized Multi-media Instructional Television) and the objective of the study was to determine the value of an interactive, computer-driven multi-media teaching terminal based upon television technology. A few of the experiences and observations are recorded in this paper.

Introduction:

COMIT was a truly unique and leading-edge system based on TV technology. It was the first known system with a standard colour TV set used as the basis of a terminal with the range of multi-media that was available to the teacher and student. The multi-media included randomly-accessible motion sequences, randomly-accessible audio segments, still images, a pen with tablet for pointing or digitizing, programmable colour and line graphics.

Fifteen modules or course segments were implemented utilizing a cross-section of the media. They represented all six UW faculties and employed a variety of teaching and learning techniques. The students' comments about their experiences and reactions, as well as their learning achievements, indicate that this type of terminal is a workable learning tool. The professors' experiences indicate that this type of system is a valuable teaching resource. COMIT posed no constraints on subject matter, teaching style or learning mode. In fact, tutorial mode was more readily implementable than in traditional CAI.

Over 550 students used the system for over 1900 student hours studying one of the fifteen modules. All classes that ran pre-tests and post-tests found a slight positive advantage in favour of the COMIT students. The increment is not statistically significant, but the trend is encouraging and rewarding for unique research hardware and first-time authors of CAI.

The use of multi-media expands the range of topics that can readily be implemented via CAI. Some of the modules would never have been tried without media. No significant increase in computer resource was required to accommodate the multi-media.

More people, vis-a-vis conventional CAI,are required to obtain effective utilization of the audio and video functions. Assistance from Audio/Visual, Graphic Services and the Language Laboratory were required and greatly appreciated.

Authoring Approach

A team approach was used. As professors' time was voluntary, we attempted to use them as subject matter experts only. Co-op students were given training in authoring, coding, and making calls. Their function was to interact with the professors in documenting the objectives and the flow of the presentation. From the professor's script or lesson notes, they prepared a storyboard which showed the detailed content on the screen and on the audio tape. As well, it included pictures and graphics. Once the level of documentation was satisfactory to the team members, the student coded it. Only one professor did his own coding. By using the team approach, we feel we best utilized the time and talent of the subject matter expert. The co-op students were challenged with new content and utilization of time. Their innovativeness produced some beneficial by-products such as code and improved techniques.

The ability to use still images under computer control and the digitizing aspect of the pen were great time savers for the team. Still images saved a large amount of verbalizing,and digitizing allowed those blackboard kinds of sketches and diagrams to be easily included.

Professors' Reactions

Quality of teaching was enhanced by allowing some of the course material to be removed from the lecture load. Pre-requisite or supplemental material was put on the terminal system. Also, the COMIT module could include more learning alternatives than could be used in a class. An example is the Economics module. The computer module would greatly assist in detecting the problems of students in a particular topic, so that they could spend the tutorial on a discussion of a specific problem.

Using the COMIT system provided an alternative presentation to class-room lectures. Some professors used their module as the only presentation of the subject, while others presented an introduction and a framework in class and used the module for review and reinforcement. In some cases the COMIT module was used to provide the student with an opportunity to experiment with the subject matter. Examples were Calculus, Chemistry and Population Sampling.

Two modules, English and Accounting, were designed to provide faster and more complete marking and information for the instructor.

In the History of Leisure, Biology and Volleyball, the ability of the COMIT system to show pictures ensured that all students saw the same angle, magnification or position of the particular movement, slide or sequence.

Student responses from all students for every question provided a new dimension of analysis, as used in the Hockey and English modules.

The ability to interact with their own material from a new perspective was a valuable experience for all.

Student's Reactions

When alternatives or pre-testing were provided, the students responded well to individualization. Where the students were expected to go through all material whether they required it or not, the frustration level was high.

The ability to work at one's own pace was appreciated only by those who worked at a rate slower than the computer response time.

The need for confirmation became more important as new material or a new learning experience was met. Unanticipated responses, keyboard accidents and hardware malfunctions are included as new experiences. Confirmation could be achieved by asking a comprehension question or duplicating the message on the screen and on the audio or by using summary panels. In modules where there was a minimum of confirmation, the room supervisor spent more time assisting the student.

Students became involved with the material. They chuckled and argued and could tolerate what the supervisors thought were long sessions at the terminal. They also told us what additional functions they would have liked included in the module. As a result, we learned how important the audio function was to students.

Being able to repeat or go back in the material is very important. Students' understanding seemed very clear until they were asked if they wished to go over work and then a high percentage wanted to review.

In Conclusion

A standard television set is acceptable as an interactive learning terminal. Using multi-media for CAI expands the ways of teaching possible subject matter of CAI. The inclusion of multi-media in a self-paced individualized module eases the authoring requirement.

The reactions and comments of professors and students indicated a positive attitude toward their CAI and COMIT experiences.

COMPUTER-AIDED TEACHING IN ENVIRONMENTAL ENGINEERING

by
Edward A. McBean
Associate Professor
Department of Civil Engineering

Abstract: A randomly-selected sample of a third-year engineering class was instructed via COMIT while the remainder of the class was instructed via the normal lecture mode. The results of pre- and post-tests used to evaluate the actual learning that occurred within both groups, is described. As well, informal feedback information is discussed that reflects the responses of the students to the computer-aided teaching mode. The utility of computer-aided teaching as learned from this experiment, in a highly technical field, is summarized.

Introduction:

Biochemical oxygen demand (BOD) is a measure of the molecular oxygen required to stabilize the decomposable matter present in a water by aerobic biochemical action. A major portion of the decomposable matter in many water bodies is the sewage treatment plant outfall. In other words, BOD is an important metric used to partially characterize the strength of pollution loads.

Because oxygen is consumed in the decomposition/assimilation process, it is important to recognize the potential of excessive levels of BOD to deplete the oxygen levels within a receiving water body. The results of excessive oxygen consumption include fish suffocation and septic waters. Because of concerns such as those introduced above, the study of BOD represents a very important aspect of environmental engineering education. Nevertheless, unlike many chemical and physical reactions which can be observed in the laboratory within a duration of a few minutes of experimentation, the biological activity that occurs within the decomposition/assimilation of the BOD occurs with time, where time is measured in terms of days. This time span makes the laboratory analysis difficult to present to the student. Additional factors that suggest the considerable extent of the complexities within BOD determination are the dependence of the biological activity upon such concerns as the specific nature of the organic material, the availability of micro-organisms, the availability of nutrients, and the temperature of the material. Because of considerations such as these, students have historically had difficulty understanding BOD and how it is exerted as a function of time.

As an alternative to the lecture presentation of the BOD-related material, the capabilities of COMIT to present the identical material was of interest. More specifically, a utilization of COMIT included the potential for employing its graphics capabilities to depict the laboratory analysis as a series of logical slides of the actions taken as a function of time in the laboratory procedure. As well, the mathematical characterizations of BOD exertion as a function of time are relatively difficult; it was felt that numerous examples and problems introduced within the COMIT presentation itself might enhance the familiarity of the student with the material, thereby increasing the learning effectiveness.

For the above reasons, a COMIT module was developed to encompass two lectures of the regular course taken by the third year engineering students at the University of Waterloo. Experiments were carried out with two successive classes of students wherein approximately forty students attended lectures in the normal manner and the randomly-selected group of about twenty were asked to attend only the COMIT proceedings.

As a means of evaluating the experiment utilizing COMIT, some feedback on the learning experience of the students was collected. This information is summarized in the paragraphs below by two different means: (1) formal - which consisted of pre- and post-examinations and (2) informal-information derived from discussions with the individuals involved with COMIT. Obviously, the formal means is the only output amenable to the numerical quantification, but it is also the one most susceptible to contamination of results.

Formal Characterization of Results

A considerable effort was expended to minimize the contamination of the results derived from the pre- and post-tests. Attention was given, for example, to ensure that no prior indication was given to the students about the tests that were to occur. The two classes which were utilized as observation groups were separated by an academic term to minimize the contamination that might result from an awareness of the experiences of the other class.

The testing of the students included a pre-test and two post-tests. All the tests were multiple choice and to the extent possible, were restricted to the material given specifically within the lecture and/or COMIT presentations.

The pre-test was given about two days before the lectures and COMIT presentations. The pre-test was given to establish their initial knowledge of the subject material specifically because some of the students may have had previous work experience dealing with concepts related to BOD and because some of the questions were somewhat logical,implying intelligent guesses were potentially fruitful. The results of the pre-test are indicated in Column I, Table 1. It is appropriate to note that purely random guessing would have attained a mean mark of about 3.2. A perfect mark on the test would have been 11.

Table 1

Results of Formal Testing

	I Pre-test	II COMIT	III Lectures
No. of individuals	60	16	42
mean	6.7	9.7	9.2
Standard deviation	1.35	0.8	1.2

About three days after the COMIT and lecture presentations the identical test was administered, the results of which are indicated in columns II and III, broken down as a function of group within the class (i.e. COMIT or lecture). It is noteworthy that a significant difference between the pre- and post-tests is apparent. Some of this apparent learning may have been guided or assisted by "recall" of the questions posed in the pre-test when subsequently the material was covered in the lecture and/or COMIT presentations. (It is not possible to separate this component of the learning that would have occurred within the two modes of presentation if there had been no pre-test, but the "recall" effect is probably quite minimal.) The most interesting aspect of the results contained in Table 1 is that there is no significant statistical difference between the apparent learning experiences of the COMIT and the lecture mode participants.

A post-post exam (about 1½ months after the COMIT/lecture presentations) was also given, as a part of their final examination within the course. The questions posed in this examination were different from those of the previous multiple choice questions; however, the questions did deal strictly with that information that was given within the COMIT/lecture presentations. Again, there was no significant difference between the COMIT and lecture derived results (see Moore and McBean, 1978). Little weight can be assigned however, to this occurrence because through conversations with the students, it appears that there was significant interaction and discussion between the students suggesting, for example, that those students who received a lecture presentation, utilized the printed notes made available to the COMIT people and vice versa.

Informal Characterization of Results

Extensive informal feedback was derived through conversations between students and professor/author, a means of communication specifically encouraged. The feedback has been subdivided into two categories, one representing those favourable toward the COMIT procedure and the second representing the unfavourable ones. Both of these categories of comments are listed along with some associated remarks within Tables 2 and 3, respectively. (These comments are felt to be self-explanatory and so will not be discussed at any length within the text in an explicit, enumerative way.) It is important, however, to isolate in particular the final three unfavourable comments about COMIT which represent what were perceived to be the most important criticisms of the utilization of the COMIT presentation. These unfavourable aspects were mentioned very frequently within the student-professor discussions. The implication of the three comments is the need for a presence of a professor when dealing with complex subject areas such as the problem of BOD. In other words, when students are being exposed to entirely new principles and concepts, the professor/class interaction as it should, and hopefully very often does occur, is very important to the learning process. Alternatively, when the nature of the learning process is more of reinforcement (and perhaps an awareness on the part of the student that the results of his efforts are being recorded and will be available to the professor), computer-aided teaching appears to have very considerable merit.

Table 2

Favourable Comments About COMIT

	Comment	Remarks
a)	COMIT is novel	Perhaps there is increased attention given by the student. Will the novelty wear off?
b)	Student can progress through the material at his/her individual rate.	
c)	Students can work in pairs and discuss elements of the material as it progresses.	This alternative was well-received by the students.
d)	COMIT requires examples to be done so that some learning is enforced.	It requires self-discipline, however, to avoid simply by-passing the material. The problem of by-passing is particularly relevant as time goes by.
e)	Elements of humour introduced occasionally into the text relieve the tedium.	
f)	With printed notes being made available, attention could be concentrated on the information rather than on the writing of notes.	The potential for distribution of printed notes exists for lectures as well as COMIT
g)	Use of colour and sophisticated graphics was noted as quite beneficial.	
h)	Students could return for review of the material at a future date.	This opportunity exists for the traditional lecture material as well via, for example, after-class student/professor discussions.

Table 3

Unfavourable Comments About COMIT

	Comment	Remarks
a)	Attention can only be held for a restricted time period. "How much COMIT exposure could you tolerate each day assuming it replaces lectures and other instructional modes"? Less than 1 hour 50% 1 - 2 hours 34% 2 - 3 hours 16% More than 3 hours 0%	As the program progressed, interest diminished considerably and noticeable hurrying resulted.
b)	A tendency exists to try to read the material as it is presented on the screen	The information should be displayed immediately.
c)	In order to answer the questions posed, it is necessary to remember numerical values contained on previous slides.	
d)	The environment of the room is very important - noise from other students, people entering and leaving, etc. is very disruptive.	This difficulty can be corrected with appropriate design.
e)	It is inconvenient for the student to ask questions of the professor.	
f)	The student cannot benefit from the professor answering other student questions.	
g)	If a professor were asked to go over a point, he would cover it in a different manner than he had the first time - this tends to clarify the problem rather than just to restate it.	

Conclusions

In a highly technical field, COMIT appears to be useful. The ability to demonstrate laboratory principles through graphical displays, the opportunity for students to progress at their own rate through the complicated material, and the availability of opportunities for review of material at a later date all suggest the considerable utility of COMIT in dealing with problems such as the introduction to BOD.

The above-indicated beneficial aspects of COMIT,however, do not appear to outweigh the detractions expressed both through numerical characterization (wherein no improvement in learning was observed with COMIT) and through informal feedback to the professor. In particular, the presence of the professor and thus the opportunity to receive answers to spontaneous questions, the ability to learn from the questions raised by fellow students and the ability to request further expansion of specific elements of the material, appeared to be serious detractors from the success of the COMIT utilization.

Overall,the benefits from COMIT utilization do not appear at this time to exceed those of the traditional lecture mode, in application to the problem of introducing relatively sophisticated environmental engineering concepts.

Acknowledgements

I wish to express my appreciation in particular to both Professor John Moore of the Department of Management Science and Mr. John Kus, formerly a student of Civil Engineering at the University of Waterloo and,in general, to the many other people within the COMIT study team that so greatly assisted the ability to derive the results described within the above paper.

Reference

Moore, J.B., and E.A. McBean, "A Comparison of the Effectiveness of Different Modes of Teaching", submitted to Journal of Computer-Based Instruction, 1978.

ARMCHAIR SURVEY SAMPLING: AN AID IN TEACHING SURVEY DESIGN

by

M.E. Thompson
Associate Professor
Department of Statistics

Abstract: A fictitious community of 583 households was set up to simulate a survey population. In two laboratory assignments, students "interviewed" householders by a quota sampling procedure, and tested the performance of several probability sampling designs.

Introduction:

When the author was invited to participate in the COMIT project, the Department of Statistics at the University of Waterloo had just begun to offer a service course called Principles of Survey Design. This course was aimed primarily at senior undergraduates in the social sciences, who are sometimes required to conduct surveys as part of their academic training, and who are frequently faced with the job of interpreting or assessing the results of surveys. The designers of the course were hoping that the fundamental ideas of sampling theory could be communicated to a reasonable proportion of these students via examples and case studies and with a minimum of mathematics. The COMIT project offered an opportunity to enrich and reinforce this program; and it was decided to try to use it to set up "labs" in which students would conduct simulated surveys at the terminals, and in this way gain some practical experience and insight into design alternatives.

Among the basic notions which were selected as being possible and worthwhile to try to illustrate were the following:

(i) the advantages and pitfalls of quota sampling;
(ii) the concept of sampling error in probability sampling;
(iii) the advantages of stratification; and
(iv) the inefficiency of a 'clustered' sampling design compared with a 'dispersed' sampling design.

All these notions were to be discussed at some length in the classroom before the students encountered them in laboratory sessions at the terminals. After the sessions, the students' results were to be discussed further in class. Thus the COMIT module would assume the role of a traditional problem assignment, except that it would make possible the handling of realistic data without requiring a great deal of computation by the students.

It was decided that the notions (i) - (iv) could appropriately form the subject of two laboratory sessions. In the first of these, called QUOTA SAMPLING, the students would "interview" a sample with prescribed composition; in the second, called STRATA SAMPLING, the students would experiment with various probability sampling designs.

The Population:

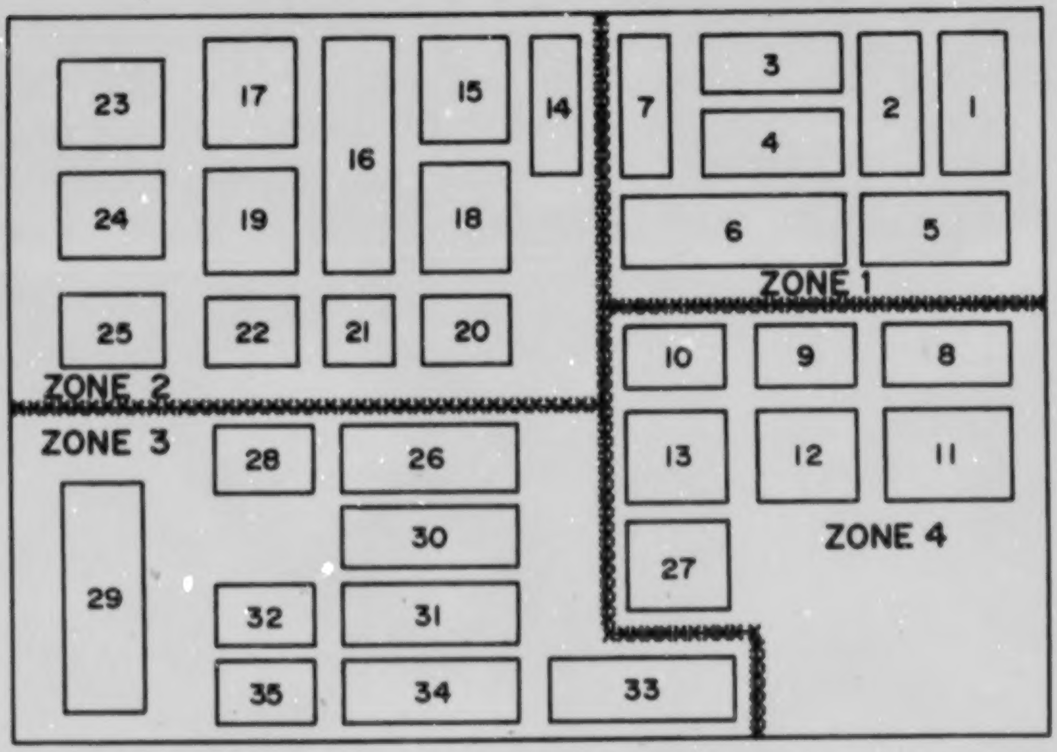
The first step in constructing the module was to set up a fictitious but relatively plausible population from which to sample. In the summer of 1975, Mr. Gerard C.F. Leung (at that time an undergraduate in Statistics) obtained tabulations of demographic data from the 1961 Census for four enumeration areas in the City of Waterloo. Using these (marginal) tabulations of sex, age group, occupation class, income, marital status, language and religious affiliation and origin, he created personal data for all inhabitants of 583 households, grouped into four zones (the enumeration areas). These data were entered in an SPSS file by the COMIT staff.

Following this, a map of the community (see Figure) was constructed with numbered street blocks, and each of the 583 households was assigned to an "address" in one of the blocks.

Each household was given a socioeconomic classification (W = high income, M = middle income, P = low income), and a block would usually contain households of one classification only.

The community included four apartment buildings with 24 units each, and four townhouse blocks with 12 units each. All other households corresponded to single family dwellings.

The population was set up so that, in its present version, occupation and income are related fairly believably. Also, family size and age of household head are associated fairly strongly with socioeconomic class (W,M or P)


23
17
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7
3
4
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24
19
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6
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ZONE 1
25
22
21
20
10
9
8
ZONE 2
ZONE 3
28
26
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12
11
29
30
ZONE 4
27
32
31
35
34
33

BLOCK MAP OF FICTITIOUS COMMUNITY

and building type. That is, the P areas contain proportionately more elderly people and people with large families; the apartments are usually occupied by one or two adults, while the town houses tend to contain young families with children. Thus the location of a sample and its socioeconomic composition tend to affect its representativity as far as such characteristics as occupation and family size are concerned.

The Quota Sampling Exercise:

In QUOTA SAMPLING, each student is given a set of "quotas" or constraints on the composition of the sample he or she is to select. For example, a typical assignment for a sample of 15 people might be the following.

TABLE 1. A typical quota assignment

	Age Group		Marital Status		Social Class			Totals
	20-34	35-54	married	single	W	M	P	
Males	3	4	6	1	2	3	2	7
Females	3	5	6	2	2	4	2	8
								15

At the terminal the student is shown a schematic block map of the town, where each block is labelled with the number of dwelling units which are so far not sampled by the student, and the building types and socioeconomic classifications which are present in the block. The student points to a block with the light pen, and is shown a blow-up of the block with buildings indicated. Touching one of these will produce a "map" of individual units if the structure is an apartment building. Once an individual unit (apartment or house) is touched, the screen shows a list of the occupants and the demographic data for each, including sex, age group, marital status and occupation. The head of the household is designated as such. The student examines the list to see if there is any one whose characteristics fit the requirements of the sample; towards the end of the exercise, when 14 of the 15 people have been found, these requirements will be very specific, e.g. the student may need a W-class married male aged 35-54.

When a suitable 'interviewee' is found, the student points to the person, who may or may not be at home. (Which of these obtains is determined by a random number generated each time a selection is made.) If the person is home, he or she may refuse to answer questions or may be incompetent to answer questions. Otherwise, the call is considered successful. As the exercise is set up at present, the student is given an "interviewer's work sheet" on which to keep track of the sample composition and on which to record, for each successful call, the address and the interviewee's answers to three questions:

Q1: Would you vote for a woman for a high government office?

Q2: Do you believe that the government should do something to control the amount of T.V. violence we see?

Q3: What is the occupation of the household head?

The answers to questions Q1, Q2 (see Table 2) are predetermined for every adult aged 20-54 in the population, and their distribution is dependent on own occupation except for married women, where the distribution is dependent on spouse's occupation. (Max Saltzman, the member of parliament has found that among his constituents in Waterloo, if husband and wife each fill out a mailed questionnaire on political issues the answers will very often be identical!)

Five students taking the course in the Winter of 1978 were each assigned a sample of size 15, in such a way that the total sample of 75 would be "representative" of the population aged 20-54 with respect to the quota "controls" (sex, age group, marital status and socio-economic classifications). Parts of the samples of two students were lost, so that the final sample size was less than 75. Table 2 shows the results of the quota sample. At least two noteworthy points emerged for discussion in class:

(i) Although the students were told to disperse their samples over the whole town, most of them found it difficult to do this and keep track of the sample composition at the same time; thus Zones 1 and 4, for example, were undersampled. Similarly, the students tended to avoid multiple family dwellings.

(ii) Zones 1 and 4 happened to be zones containing the largest proportions of "Yes" answers to Q2. The location bias in (i) undoubtedly contributed to the fact that the survey results estimate (wrongly) a preponderance of "No" answers.

(At the same time, with respect to (ii) it can be shown that a simple random sample of size 75 could easily yield the same 'incorrect' results. It is to be hoped that in future years classes will be large enough to make the results of the exercise possibly more conclusive.)

The students were graded according to the correctness of their sample compositions, the 'dispersion' of their samples, and their coding of responses to Q2, which were given in the form of sentences, like "Of course not, but

TABLE 2: Results from Quota Sampling Experiment

	Sample Totals						Sample Percentages	True Population Percentages
Student:	JY	PH	FY	MW	JD	All		
Occupation Class of Household Head								
Managerial	3	4	4	1	4	16	21.9	22.7
Professional	3	4	2	1	0	10	13.7	16.3
Clerical	1	1	0	3	2	7	9.6	10.9
Sales	0	2	1	1	2	6	8.2	8.2
Service	0	0	0	0	0	0	0	3.2
Craftsman	5	3	5	6	6	25	23.2	26.8
Labourer	0	0	0	0	0	0	0	4.0
Other	3	1	1	3	1	9	12.4	7.9
	15	15	13	15	15	73	100.0	100.0
Answer to Q1								
Yes	10	9	10	10	10	49	68.0	74.3
No	3	4	1	4	5	17	23.6	20.5
Don't Know	2	2	1	1	0	6	8.4	5.2
	15	15	12	15	15	72	100.0	100.0
Answer to Q2								
Yes, strongly	2	3	2	1	2	10	13.9	17.0
Yes	6	5	3	2	3	19	26.4	34.9
No opinion	2	0	2	5	3	12	16.7	11.2
No	4	6	4	5	6	25	34.7	26.0
No, strongly	1	1	1	2	1	6	8.3	10.9
	15	15	12	15	15	72	100.0	100.0
Location								
Zone 1	5	1	1	-	1	8	13.8	18.9
Zone 2	3	3	3	-	4	13	22.4	19.2
Zone 3	7	6	2	-	7	22	37.9	31.6
Zone 4	0	5	7	-	3	15	25.9	30.3
	15	15	13	-	15	58	100.0	100.0
Building Type								
Townhouse	0	0	0	-	0	0	0.0	8.2
Apartment	1	0	0	-	1	2	3.4	16.5
Other	14	15	13	-	14	56	96.6	75.3
	15	15	13		15	58	100.0	100.0

they ought to do something about all them dirty soap operas" (no,strongly). They found the exercise itself reasonably enjoyable and not difficult (according to one student, not difficult enough). They seemed to be quite interested in the results of the combined sample.

The Probability Sampling Exercise:

The exercise called STRATA SAMPLING is more technical in nature. Here the student is not to "interview" occupants of the households, but is required to "design" a probability sample for gathering household characteristics and to "test" the design.

The first thing that the student is asked to do is to "stratify" the blocks of the town into non-overlapping "strata". He or she may designate the town as one large stratum, or may stratify the town into the four zones, or may assign blocks to strata in any other way. The sample of households will then be the union of subsamples, one from each stratum. The student is asked to specify the number of households to be selected in each of the subsamples. He or she must then specify the sampling design to be used for the subsamples, and has four options (see [1] for definitions of the terminology):

A: simple random sampling of households
B: systematic sampling of households
C: two stage sampling, in which a simple random sample of blocks is selected first, and the households to be sampled are selected from these blocks
D: further stratification by building type, followed by simple random sampling within strata.

If C or D is chosen, there are more detailed sample size specifications to be made.

Once the design is completely specified, the program implements the design once, and displays estimates of quantities like the proportion of households with head having a specified occupation, or the average number of children aged 0-4 per household; together with these are shown estimated standard errors of estimation. It also prints out the true population value for each quantity and the theoretical standard error of estimation under the design.

In the associated laboratory assignment in the Winter of 1978 the students were asked to try out the various options, with design parameters given to them, for a sample of total size 75. They were then asked to examine the results to see if they were in accordance with theory. For example, theoretically a dispersed sample (systematic or stratified by zone and allocated to the zones proportionally) should be relatively efficient, and tend to have lower theoretical standard errors than a clustered sample (two stage with several households chosen from each sampled block). The students were asked to compare the performance of these samples with that of the quota sample in estimating the distribution of occupation of household head. Finally, they were asked to design a sample which would be more "efficient" than any of the prescribed ones for estimating the average number of preschool children per household.

An unexpected feature of this exercise was the finding that as in real life, there were results for some of the prescribed designs which did not apparently agree with theory! Apart from some confusion, the effects of this were largely beneficial, since the author was forced to spend a good deal of time and effort trying to convince the students that the theory could be relied upon in general.

Conclusions:

Because of the small size of the class on which the module was tested, and because of difficulties encountered with the operation and scheduling of the second exercise, conclusions about the effectiveness of the module as a teaching tool must be tentative. Continued use of the module in future terms is planned, however, and more definite conclusions should be available at a later date.

Happily it appeared by the end of the second exercise that the notions (i), (iii) and (iv) mentioned in the Introduction had been conveyed to most of the students (more could have been done with (ii), in a classroom Monte Carlo study, if more time had been available). In addition, the impression gained was that this sort of simulation of survey situations could be especially valuable as a device for enrichment of the curriculum, as well as a means of reinforcing concepts which have been encountered in lectures and books.

Assuming this to be the case, the author feels that the work described here, particularly the STRATA SAMPLING part, could be developed further. Obvious improvements would follow the direction of making the simulation more realistic; for example, formulae for measurement of sampling costs associated with the various options could be incorporated, and students could be asked to take travelling and interviewing costs into account when developing their designs. At the same time, as became very clear in the course of the module development, the larger the number of choices to be made available to student and instructor in the simulated survey situation, the more intricate and costly the job of writing and making available the associated software. Thus the author is grateful to the COMIT organizers and staff for making this experiment possible, and particularly to the programmer, Mr. G. Suggitt, who worked for many long hours to see the project through most capably.

Reference:

[1] S. Sudman, Applied Sampling, Academic Press, New York, 1976.

A COMIT MODULE ON A TOPIC FROM ADVANCED CALCULUS

by

Bev Marshman

Department of Applied Mathematics

Abstract: This is a report on an experiment conducted with three successive second year calculus classes, in which part of each class was taught the concept of uniform convergence of a sequence of functions by an interactive COMIT module, while the remainder were given lectures in the traditional manner. An outline of the teaching techniques used in the module is followed by a comparison of the performances of the two groups on a pre-test, post-test, mid-term, and final exam. Finally, an attempt is made to evaluate the significance of any differences in the above results, and to assess the assets and liabilities of computer-aided teaching in general.

Introduction:

This project was very much a joint effort of myself and L. J. Makela, then a graduate student in the Department of Computer Science. Basically, I developed the course content, while he took charge of the programming, although there was much interaction at all stages. Since details of the software are included in his master's thesis [1], I would refer anyone interested in the computing aspects of the module's development to that source. In this report , I'll generally stick to a discussion of the teaching techniques we utilized.

Our principal aims were threefold. First, we wanted to see if the graphics capabilities and interactive nature of the COMIT facilities could be used effectively to convey the concept of uniform convergence of a sequence of functions to second year calculus students (irrespective of the effort and cost involved). Secondly, we wanted to compare the performance, both short-term and long-term, of the students who learned the topic through the COMIT module (approximately one-third of each group) with that of the remainder, to see if there were any detectable differences. Finally, we wished to assess, as far as possible, the advantages and disadvantages of this medium in general.

The Module:

The subject material of the module, uniform convergence of a sequence of functions, was chosen for a variety of reasons: it is most easily interpreted geometrically, and would thus utilize the graphics capabilities of COMIT; it is a concept which frequently gives students difficulty, and would, we hoped, truly test the system as a teaching device; finally, it is about the right length. The first stage was development of a set of behavioural objectives, which break the topic down into distinct steps, each building on the previous ones until the 'terminal objectives' are reached. These steps were then further dissected, examples selected, and a flow chart designed for each. Several months of programming followed, and the module was ready for use early in 1977. (For more details on all aspects of the structure of the module, see [1].)

The main teaching technique used was a combination of allowing the students to display for themselves the graphical behaviour of the functions involved while at the same time continuously soliciting answers to pertinent questions. In the following, one of the principal ideas contained in the module is presented (although not verbatim), along with explanations of what the student might have done and seen in that portion of the module; hopefully, this will clarify how the above-mentioned technique was utilized. (Anyone not interested in the actual content of the module can ignore the balance of this section, as it is not essential to the remainder of the report.)

A sequence of functions, denoted $f_n(x)$, is just a set of functions of a variable x, one for each value $n = 1,2,3,\ldots\ldots$. For example, consider the sequence $f_n(x) = x^n$, several terms of which are shown in Figure 1. Note that each term of the sequence is a single function of x .

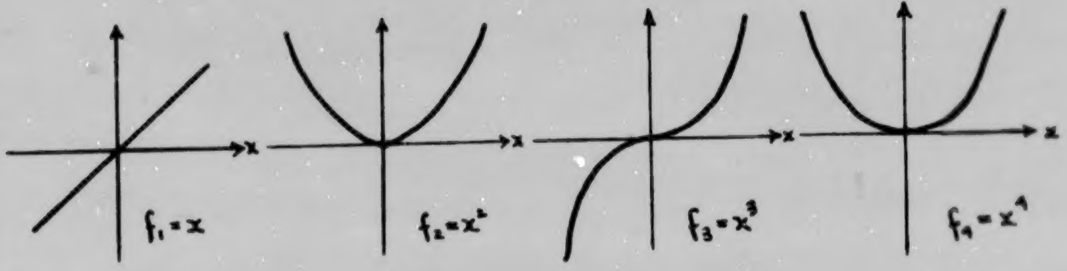


Figure 1

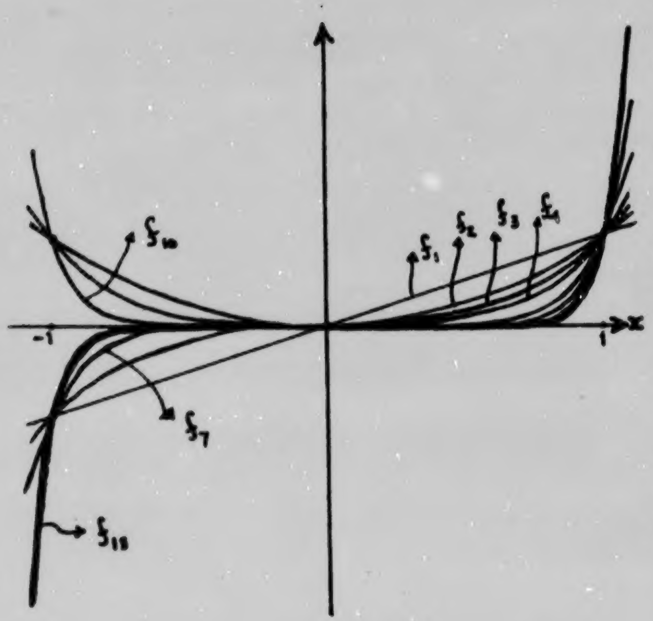


Figure 2

In the COMIT module, the student could choose to see any terms desired, but each was superimposed on the previous graphs, with the latest displayed in bright white and the former choices dimmed to a pale green. Thus a student who had asked, in turn, for terms $n = 1,2,3,4,7,10$ and 13 on the interval $[-1.1,1.1]$ would, in the end, see Figure 2 displayed on the screen, with the graph of $f_{13}(x)$ displayed most brightly. (Note: To facilitate the fit, the vertical scale in this figure has been compressed.)

This example was then re-used to illustrate the notion of point-wise convergence: the sequence $f_n(x)$ converges pointwise at $x = x_0$ if the sequence of real numbers $f_1(x_o)$, $f_2(x_o)$, $f_3(x_o)$,..... approaches a certain value as n gets larger. For example, if $f_n(x) = x^n$, and $x_o = \frac{1}{2}$, we get the sequence $\frac{1}{2}, (\frac{1}{2})^2, (\frac{1}{2})^3, \ldots$, or $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \ldots, \frac{1}{2^n}, \ldots\ldots$ which obviously approaches zero as n gets large. (When this happens, we say the sequence has a limit and write, for example, $\lim_{n\to\infty} \frac{1}{2^n} = 0$.) On the other hand, if we choose $x_0 = -1$, we get $(-1), (-1)^2, (-1)^3, \ldots$, or $-1, 1, -1, 1, -1, \ldots$ which does not approach any particular value as n gets larger. A moment's thought will convince you that the sequence x^n will only have a limit for values of x such that $-1 < x \leq 1$; i.e. either x is a fraction, so that x^n approaches 0 as n gets large, or $x = 1$, which gives the sequence $1, 1, 1, \ldots$.. We say, then, that the sequence $f_n(x) = x^n$ has limit function

$$f(x) = \begin{cases} 0 & \text{if } |x| < 1 , \\ 1 & \text{if } x = 1 . \end{cases}$$

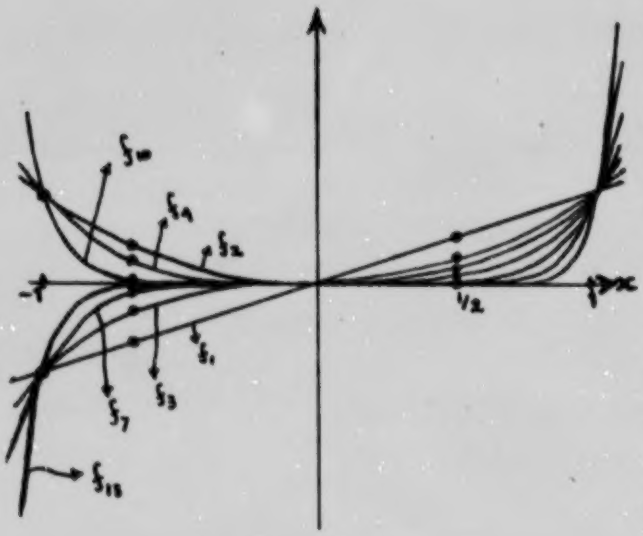


Figure 3

We again utilized graphics to illustrate this in the COMIT module; the convergent sequences for $x = \frac{1}{2}$, and $x = -\frac{2}{3}$, for example, are displayed as the vertical rows of dots in Figure 3. It is clear that they approach zero, while $x = -1$, say, oscillates between 1 and -1. (Here, 'approach zero' means the dots get arbitrarily close to the x-axis as $n \to \infty$.)

Once the concept of pointwise convergence had been presented, the student was allowed to 'play' with several other examples of sequences, using the graphics capabilities of the system to assist in finding for which values of x each sequence converged, and to what limit function $f(x)$. The student's grasp of the material was constantly monitored by a variety of types of questions (including some multiple choice), with immediate feedback giving the proper reasoning when errors were made.

It should be pointed out that the above is a simplification of the actual material presented (mathematical rigour not being the object here); the aim was simply to demonstrate that the ideas could be handled graphically, and to give a hint of how this was done. (Complete flow charts of actual material are contained in [1].)

Structure of the Experiment:

From each of three different classes of students in Math 230B (Advanced Calculus), we selected ten students to use the module by first ranking them according to their Math 230A grades, then selecting every third student; the remainder of each group attended the usual two lectures on this topic, all being given basically the same two lectures by the author. All the students were given, unannounced, a pre-test just prior to the experiment (to measure their background in the relevant area), and a post-test, immediately following, to measure their grasp of the topic at that point. In addition, grades on the relevant questions on mid-term (except for group 2, where no mid-term was given) and final examination were recorded for each student, to serve as a measure of long-term retention of the material, although it should be noted that they are probably not very reliable indicators of any effect of the module or lectures encountered initially, since by that time many other factors will have come into play.

The students who used the module were given a set of notes which roughly paralleled the material in the module, except the interactive portions. These same notes were used as a basis for the lectures given to the remainder of each group, in hopes that all students would be exposed to more or less the same material.

Statistical Analysis:

I wish to thank G. W. Bennett of the Department of Statistics for the summary which comprises the balance of this section; further details on the analysis may be obtained from him. Data used are the scores on the above-mentioned tests and exams, converted to percentages. Throughout the following, PRE and POST refer to pre-test and post-test grades, respectively, COMIT and NON-COMIT refer to the portions of each group using the module and attending lectures, respectively, and T1, T2, T3, and T4 refer to pre-test, post-test, mid-term, and final examination grades, respectively.

Table 1 illustrates the performances of COMIT and NON-COMIT on the pre-test and post-test for each of the three groups. The figures in brackets indicate the number expected in that cell under the hypothesis that there is no relationship between COMIT and POST > PRE. In all three groups, the figures are consistent with this hypothesis; that is, any differences are well within the allowable error.

An analysis of variance on $-\ell n(\text{grade})$ was done as a nested factorial with main factors COMIT, NON-COMIT, T1, T2, T3, T4, and students as a factor nested within the COMIT factor. This analysis shows a significant time effect for Groups 1 and 3, but with no significant differences between COMIT and NON-COMIT insofar as their patterns go. In Group 2, there were no significant effects, although the error terms were large enough to make differences difficult to detect.

Table 2 gives the means of grades on the various tests for each group.

In summary: (i) there is no evidence that COMIT versus NON-COMIT is related to the fraction of students with POST > PRE; (ii) there is some evidence that over time, the students learn, in that T3 is greater than T1 and T2, although again, there is no evidence that COMIT students behave any differently from NON-COMIT students in this respect.

It is important to note that the various marks measure performance under different conditions in that T1 and T2 are local to the

	GROUP 1			GROUP 2			GROUP 3		
TYPE OF STUDENT	NO. WITH POST > PRE	NO. WITH POST ≤ PRE	TOTAL (30)	NO. WITH POST > PRE	NO. WITH POST ≤ PRE	TOTAL (32)	NO. WITH POST > PRE	NO. WITH POST ≤ PRE	TOTAL (27)
COMIT	7 (6.7)	3 (3.3)	10	6 (5)	4 (5)	10	7 (6.7)	3 (3.3)	10
NON-COMIT	7 (10.3)	13 (9.7)	20	10 (11)	12 (11)	22	11 (11.3)	6 (5.7)	17
TOTALS	14	16	20	16	16	32	18	9	27

Table 1: Comparison of COMIT and NON-COMIT Students Results on Pre-test and Post-test. Three separate groups of students were involved.

	GROUP 1				GROUP 2			GROUP 3			
	T1	T2	T3	T4	T1	T2	T4	T1	T2	T3	T4
COMIT	.729	.821	.821	.780	.494	.594	.630	.538	.713	.787	.480
NON-COMIT	.607	.655	.869	.663	.632	.639	.564	.479	.686	.719	.414
COMMENT	This difference is mostly T3 improvement over T1 and T2.				No significant time pattern.			The bulk is due to the steady rise T1 → T2 → T3 and the sudden fall T3 → T4, although a significant T2-T1 component does not exist.			

Table 2: Comparison of Mean Grades for COMIT and NON-COMIT Students on Pre-test (T1), Post-test (T2), Mid-term Test (T3) and Final Exam (T4).

material, whereas T3 is only as a component of about half the course, while T4 is as a component of the whole course. Study preferences may influence T3 and T4.

Conclusions:

Our primary aim, that of testing the capabilities of COMIT as a teaching device for mathematical material, was fully achieved, and with great success. Aside from some complaints about the response time of the computer, over which we had no control, student reaction to the module was very favourable. The following is a selection of more or less typical quotes from the written comments handed in on completion of the module:

> "I feel that seeing the graphs and being able to experiment with various n's and x's greatly helped me understand the concept of uniform convergence...... Another advantage of this teaching method is that it requires active participation of the student, where in a class, full attention is not always given."

> "... I was forced to respond to questions all the time and thus take part in what was going on...."

> "The graphical aspect certainly added to the comprehension..."

> "Being able to go at your own pace and having things repeated when you didn't catch a concept was helpful. The use of examples with immediate feedback and explanations of how to do the questions was good also."

> "The advantage was that I had to be on the alert all the time and thus I learned more about the topic. In class I normally feel sleepy sometimes ..... The idea of asking questions after each section was a good one. It tested the student's ability to retain the work."

Some of the students thought even more examples should have been included; some would have preferred two one-hour sessions rather than one two-hour, as their attention flagged towards the end. It should also be pointed out that the novelty of the situation probably contributed somewhat to their enthusiasm. I feel quite strongly, however, that the immediacy of the feedback is a really valuable asset of computer-aided instruction; we don't ever learn much by listening to someone talk about something; we learn by trying things out, making errors, correcting for them, and trying again. It is in this aspect that an interactive system excels.

Regarding our second aim, that of comparing the performances of COMIT versus NON-COMIT students, the statistical results speak for themselves: any differences are well within allowable error. The post-test grades, which are certainly the measures most closely related to the material presented in the module, were obtained on a ten-minute quiz, and it could be questioned whether such a quiz could test anything in depth. Nevertheless, it was designed to test whether their knowledge was at a level acceptable for that topic in that particular course, and as such represents as extensive a performance test as would ever be required. Keeping this in mind, we conclude that using COMIT did not produce perceptibly better performance (at least as we measure it) from the COMIT students over the NON-COMIT students. Whether that means they did or did not understand the concepts any better is quite another question!

Our third and final aim was to assess some of the advantages and disadvantages of the medium in general. The obvious ones have already been mentioned: the student sets the pace at which the material is covered; the constant stimulus provided by the interaction with the terminal keeps interest up, and accelerates assimilation of the concepts; the explanations given after each error provide a degree of 'personal' attention impossible in a lecture where there are more than half a dozen students. It is true that students using an interactive system like COMIT do not get the benefit of hearing the wider variety of questions and answers, and discussion in general, that might arise in a lecture situation, but in most cases I think its other assets outweigh this, particularly since many courses nowadays are given in huge lecture sections where little or no discussion occurs.

On the negative side, we found the preparation time for this type of instruction to be astronomical (over 160 hours total for author and programmer); hopefully, this was at least partially attributable to inexperience. I certainly learned an awful lot about structuring a lecture, which was definitely worthwhile. It would also be nice to eliminate problems like slow response time related to backup computing facilities. Finally, it should be pointed out that there has been no consideration of costs here. My general feeling is that, given the extensive effort necessary for preparation, my preference would be to use such a system for short modules on the more difficult topics of a course, with the students having access to these at their leisure.

All in all, I found the COMIT project most worthwhile and enjoyable, and at this point wish to extend my thanks to J. B. Moore, E. Elkeer, L. J. Makela, and the students themselves, for their co-operation and assistance.

Reference

[1.] Makela, L. J., CAI on COMIT: The Development and Implementation of a Computer-Assisted-Introduction Course Segment for use with Math 230B , Master's Thesis, Department of Computer Science, University of Waterloo, Nov. 1977.

COMPUTER-ASSISTED INSTRUCTION
IN ORGANIC SYNTHESIS

BY

V. Snieckus
Associate Professor
Department of Chemistry

Abstract: A module useful in the instruction of organic synthesis was developed. Using the Corey approach, retrosynthetic/synthetic schemes for six organic molecules of increasing complexity were programmed and tested in a fourth-year undergraduate course. A portion of a simple synthesis is presented and analyzed. Problems encountered are discussed and potential solutions are proposed. The module was evaluated by both instructor and student input and it is concluded that it serves to enhance understanding of and develop skill in the design of organic synthesis.

Introduction:

Response to a definition of the term organic synthesis may vary from "the fruits of organic gardening" to "the operation of an oil refinery" and depends on the background of the respondent. In very general terms, organic synthesis is the preparation of carbon-containing molecules of varying complexity from simple components by a series of rational procedures. Very loosely, this can be translated as "fooling around with nature" since most simple molecules arise from natural sources, e.g. oil, coal, plants. We are of course highly dependent on these resources for our material (e.g. clothing), health (e.g. drugs), and energy (e.g. gasoline) needs. In view of the increasing scarcity of these resources, we need reliable, specific, and economic organic syntheses in order to meet our future needs.

Therefore, instruction in organic synthesis is a significant component of the education of a chemistry student. In our department, the undergraduate is widely exposed to this subject as practised in academic and fine chemical (e.g. pharmaceutical) laboratories as well as in large-scale industrial plants.

Fig. 1 ORGANIC SYNTHESIS IN THE CLASSROOM. CIRCA 1968	Fig. 2 ORGANIC SYNTHESIS IN THE CLASSROOM. CIRCA 1978
1. Myriad of Chemical Reactions	1. Synthesis of Selected Molecules
2. Information Storage by and Retrieval from Human Mind	2. Practical Approaches, Alternate Routes
3. Uncorrelated, Undigested Facts	3. Highlight Important Chemical Reactions
4. Attempt to cover "everything"	4. Extensive Secondary and Tertiary Literature Base
5. Rote Learning	5. Development of Useful Data Bank - Responsibility of Student
"Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?" T.S. Eliot	6. Take-away exams

A decade ago, instruction in organic synthesis (Fig. 1) was based on committing to memory a large amount of factual information, an ever-increasing tower of building blocks which were poorly interconnected and difficult to assimilate and correlate. An attempt was made to cover "everything" and examinations were regurgitations of rote learning. The modern approach to synthesis (Fig. 2) is to show how chemists go about constructing complex molecules by using a limited number of carefully selected cases. Alternate routes to a given target molecule are desirable to illustrate conceptual and practical differences. Instead of a myriad of reactions to memorize, the student learns a few important processes whose ramifications he studies outside of the classroom in the extensive secondary and tertiary literature now available. Therefrom, the student establishes a data bank of reactions which he uses for non-supervised, take-away examinations. In the future, points 4 and 5 of Fig. 2 will no doubt become the responsibility of computers.

Corey [2] is responsible for the initial developments in computer-assisted organic synthesis. His program (LHASA) and more recent independent versions (PLATO [3], SYNCHEM [4]) are highly sophisticated aids for planning of complex syntheses. The COMIT Project presented the opportunity to develop a comparatively simple module to be used for undergraduate instruction.

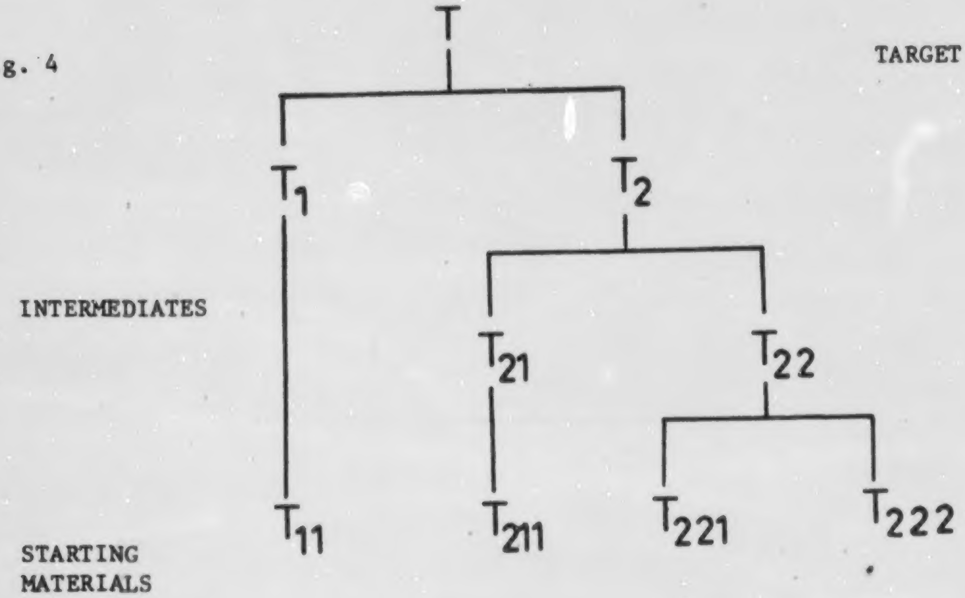
Fig. 3 OBJECTIVES

1. To enhance understanding of principles of organic synthesis design
2. To develop skill and confidence in planning organic synthesis
3. To reinforce concepts taught in the classroom
4. To allow self-paced approach
5. To provide for constant, individualized evaluation
6. To assist students at several levels of proficiency

Objectives and Methods

In devising the Organic Synthesis Module (hereafter, ORGSYN), we set objectives which require no elaboration (Fig. 3). The method we used is based on the Corey model of Retrosynthetic Analysis [1]. (Fig. 4) A given target molecule (T) chosen for synthesis is dissected into a set of intermediates (T_1 and T_2) which are viable precursors of T by a single real (laboratory) chemical reaction. Iteration of this procedure for each intermediate leads to a "tree" of further intermediates, e.g. $T_2 \rightarrow T_{21}$ and T_{22}, until simplication of the hierarchy results in molecules that are commercially available. These are our starting materials, e.g. T_{11}, T_{211}, T_{221}, T_{222}. Thus the overall analysis, target to starting materials, is a process of working backwards relative to real laboratory experimentation.

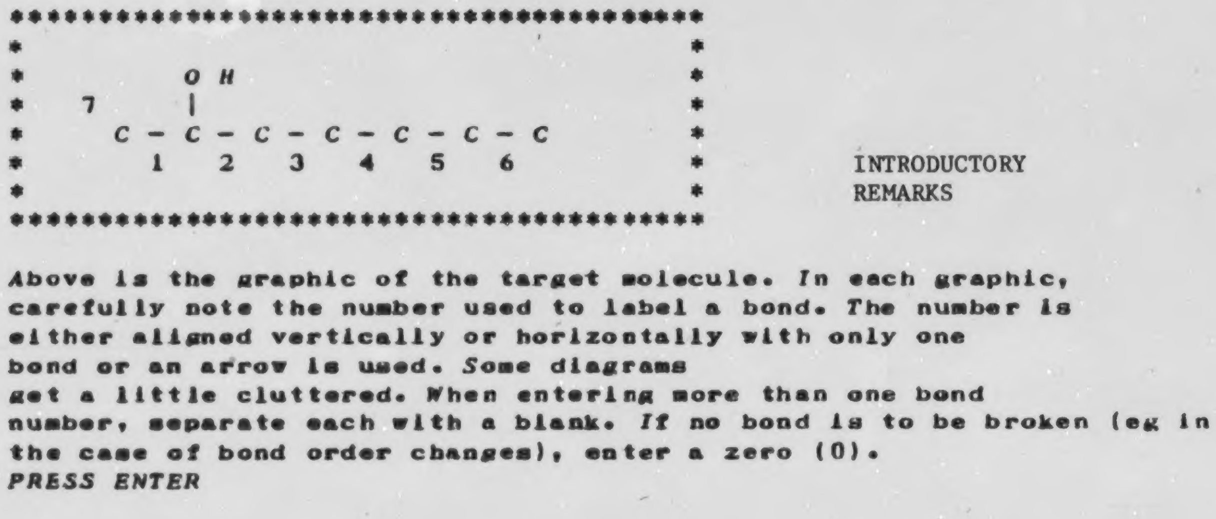
Fig. 4



In ORGSYN, six target molecules (T) of increasing complexity were subjected to Retrosynthetic Analysis. These were 2-heptanol, iso-butylbenzene, 1-phenyl-3-pentanone, α-curcumene, lavandulol, and cis-jasmone [1]. For any given T, we restricted ourselves to three first-hierarchial intermediates T_1, T_2, T_3 which we hoped correctly predicted the most likely dissections students would pursue. Once an intermediate (T_1) was correctly identified, the student was asked to specify the reaction environment chosen from tables of reagents, solvents, and temperatures under which T_1 could be converted into T, i.e. to approximate actual laboratory conditions (extracted from the literature) for this conversion. This cyclical process was continued until the student received the message that a given target (e.g. T_{11}) was a starting material. Since ORGSYN was programmed in APL, communication required no knowledge of computer language.

The initial phases of a simple synthesis in ORGSYN with appropriate explanations are illustrated in Figs. 5 and 6.

Fig. 5



```
****************************************
*                                      *
*           O H                        *
*     7     |                          *
*       C - C - C - C - C - C - C      *
*         1   2   3   4   5   6        *        INTRODUCTORY
*                                      *        REMARKS
****************************************

Above is the graphic of the target molecule. In each graphic,
carefully note the number used to label a bond. The number is
either aligned vertically or horizontally with only one
bond or an arrow is used. Some diagrams
get a little cluttered. When entering more than one bond
number, separate each with a blank. If no bond is to be broken (eg in
the case of bond order changes), enter a zero (0).
PRESS ENTER
```

Fig. 5 continued

```
****************************************
*                                      *
*          O H                         *
*    7     |                           *
*     C - C - C - C - C - C - C        *
*       1   2   3   4   5   6          *
*                                      *
****************************************
SUBSTANCE: 2-Heptanol IS THE TARGET MOLECULE
ENTER BOND NUMBER(S) TO BE BROKEN
2
NO, PRESS ENTER TO TRY AGAIN
```

TARGET MOLECULE (T)

REJECTED BOND 2 CLEAVAGE

```
****************************************
*                                      *
*          O H                         *
*    7     |                           *
*     C - C - C - C - C - C - C        *
*       1   2   3   4   5   6          *
*                                      *
****************************************
SUBSTANCE: 2-Heptanol IS THE TARGET MOLECULE
ENTER BOND NUMBER(S) TO BE BROKEN
7
GOOD, THE NEXT STEP IS TO SELECT FUNCTIONAL GROUPS
TO ATTACH TO THE FRAGMENTS. PRESS ENTER.
```

ALLOWED BOND 7 CLEAVAGE

```
LEFT FRAGMENT
****************************************
*                                      *
*                                      *
*    7     |                           *
*     C - C - C - C - C - C - C        *
*       1   2   3   4   5   6          *
*                                      *
****************************************
1 Carbonyl                    5 Hydrogen
2 Nitrile                     6 Grignard
3 Carboxylic ester            7 Hydroxy
4 Bromide
ENTER REAGENT INDEX FROM TABLE FOR  -LEFT-  FRAGMENT
1
FINE, YOU MUST NOW CHOOSE A REACTION ENVIRONMENT
TO PRODUCE THE TARGET FROM THE RESULTANT(S).
PRESS ENTER TO CONTINUE.
```

ATTACH FUNCTIONAL GROUP

```
LEFT RESULTANT
****************************************
*                                      *
*            O                     <-- * INTERMEDIATE
*    7       ||                        *
*      C - C - C - C - C - C - C       * T1 = NEW
*          1   2   3   4   5   6       * TARGET
*                                      *
****************************************
1 LAH
2 Alkoxy base
3 Mg turnings
4 Nothing
5 H3O+
ENTER THE REAGENT INDEX
1
****************************************
*                                      *
*            O                         *
*    7       ||                        *
*      C - C - C - C - C - C - C       *
*          1   2   3   4   5   6       *
*                                      *
****************************************
1 Alcohol
2 Et2O
3 Nothing
ENTER THE SOLVENT INDEX
2
****************************************
*                                      *
*            O                         *
*    7       ||                        *
*      C - C - C - C - C - C - C       *
*          1   2   3   4   5   6       *
*                                      *
****************************************
1 N/A
2 RT
3 Reflux
ENTER THE TEMPERATURE INDEX
2
CORRECT, PRESS ENTER


****************************************
*                                      *
*            O H                       *T -> T1 COMPLETE
*    7       |                         *NOW MUST DO
*      C - C - C - C - C - C - C       *
*          1   2   3   4   5   6       *T1 -> T12
*                                      *
****************************************
YOU HAVE CORRECTLY PROGRESSED FROM THE TARGET ABOVE
TO THE NEW TARGET(S) BELOW. PRESS ENTER TO CONTINUE
WITH THE NEW TARGETS.
```

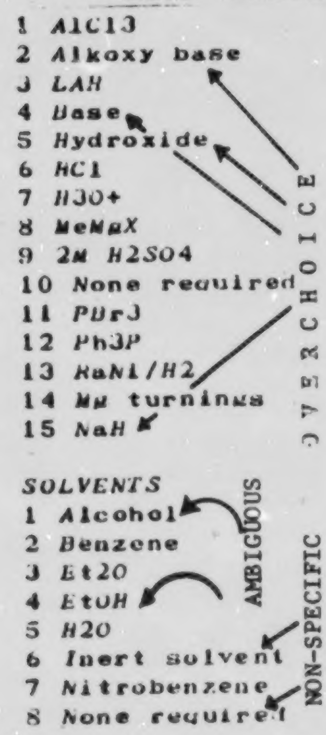
Results and Discussion

The testing ground for ORGSYN was the Winter, 1978 version of Chemistry 465, a fourth year undergraduate course in organic synthesis. A total of 14 students each completed at least 5 of the 6 programmed syntheses. The instructor was present at all sessions. Printouts of student answers were available for analysis by students and instructor.

Student adaptation to the format of ORGSYN was facilitated by prior exposure to Retrosynthetic Analysis in the classroom. There was visible satisfaction in seeing the presentation of molecular fragment (T_1) after the correct bond had been broken (Fig. 5). Once this was done, the student was committed to a particular synthetic approach which was at least in part several steps beyond T_1 in his mental "tree". Since bond cleavage and selection of a functional group are logically connected, correct response to the latter followed rapidly correct response to the former. As expected, those students who took a "random walk" approach to the cleavage of the correct bond (no mental "tree") had difficulty in selecting the right functional group. In the course of the operation, several ambiguities in functional group listings were noted, e.g. attach "nitrile" ($C\equiv N$) resulted in the change of an existing C* in a fragment to a $C\equiv N$ (i.e. $C^*\equiv N$) whereas attach "ethoxycarbonyl" (CO_2Et) led to appending a CO_2Et onto an existing C* (i.e. $C^* - CO_2Et$). Such ambiguities may be corrected by modification of the functional group tables.

The menu tables of Reaction Environment (Fig. 6) was the Dr. Jekyll and Mr. Hyde of ORGSYN. On the "good side", it forced students to think about practical reaction conditions for each retrosynthetic step that they undertook. This led to an increasing awareness for the necessity of rational analysis in the design of organic synthesis. Secondly, it confronted them with the realization that they had largely ignored reaction conditions in previous study of organic chemistry, an unforgivable admission to chemists, engineers, and the discriminate cook! On the "bad side", it was soon discovered that although menu tables were appropriate for the simple syntheses (e.g. Fig. 6), they were ill-defined for the more complex cases. Since menu tables for any given chemical operation contained information which was the sum total of all reagents, solvents, and temperatures coded in the synthesis of a target molecule, they became long and awkward with the following consequences: a) for a given reaction, several reagents would appear differing little in their chemical properties (Fig. 7). The good student was faced with selecting one of these in a list which contained numerous other choices. The poor student was in a worse position in that he was also tempted by the other choices; b) in the solvent menu, the correct answer " inert solvent" was listed among several other defined solvents (e.g. benzene, ethanol) which could in theory also serve for the reaction under consideration; and c) in the temperature list, lack of definition (N/A = not critically important to the reaction) and over-specification (0°C vs 10°C) provided serious difficulties. All of these problems were compounded by the fact that only one combination of reagent, solvent, and temperature was accepted as the correct answer. Thus a number of students, after several rational approaches to obtain the correct combination, resorted to the "Monte Carlo" method. In tables containing ten or more entries for each of reagents, solvent, and temperature, this approach led to further frustration.

Fig. 7 REACTION ENVIRONMENT TABLES



REAGENTS

1 AlCl3
2 Alkoxy base
3 LAH
4 Base
5 Hydroxide
6 HCl
7 H3O+
8 MeMgX
9 2M H2SO4
10 None required
11 PBr3
12 Ph3P
13 RaNi/H2
14 Mg turnings
15 NaH

SOLVENTS
1 Alcohol
2 Benzene
3 Et2O
4 EtOH
5 H2O
6 Inert solvent
7 Nitrobenzene
8 None required

Fig. 8 REACTION ENVIRONMENT

```
******************************************
*   4-        |                          *
*   5-      /   \      -3                *
*   6-     |       C6H4-p-Me             *
*   7-      \                            *
*      8-     ||                         *
*            PPh3                        *
******************************************
BOND CHOSEN WAS: 8
RESPONSF FOR LFFT FRAGMENT: 1 Bromide
REACTION ENVIRCNMENT
RESPONSE FOR REAGENT: 12 Ph3P
RESPONSE FOR SCLVENT: 2 Benzene
RESPONSE FOR TEMP:    2 Reflux
SECOND RE
RESPONSE FOR REAGENT: 2 Alkoxy base
RESPONSE FOR SCLVENT: 1 Alcohol
RESPONSE FOR TEMP:    4 R.T.
NO MATCH
RESPONSE FOR REAGENT: 2 Alkoxy base
RESPONSE FOR SCLVENT: 1 Alcohol
RESPONSE FOR TEMP:    1 N/A
NO MATCH
RESPONSE FOR REAGENT: 2 Alkoxy base
RESPONSE FOR SCLVENT: 1 Alcohol
RESPONSE FOR TEMP:    2 Reflux
NO MATCH
```

Judicious pruning of the Reaction Environment tables for excessive information, ambiguities, and lack of specificity will lead to direct solutions of the above problems. Perhaps the greatest difficulty is point a) where it can be envisaged that the requirement for several reagents with very similar chemical behavior cannot be avoided in multi-step synthesis. In such cases, use of separate tables for individual steps rather than the present composite listing presents a potential solution which, however, may not be practical from the computer programming point of view.

The other major difficulty concerns the lack of a feedback mechanism in the Reaction Environment tables which would guide and encourage students rather than promote adoption of the "Monte Carlo" approach (Fig. 8). The solution most beneficial to the student would be the provision of Error and Hint Messages after a NO MATCH result. These could be in the form of questions (e.g. for Solvent: "Have you considered the solubility factor?";for Reagent: "Have you given careful thought to base strength?") or direct statements (e.g. for Temperature: "The high temperature will cause a secondary condensation";for Reagent: "This reagent is not selective for your desired purposed.") After further lack of success (e.g. maximum 3-4 failures) a Giveaway Message would indicate the correct response as well as a reference to a standard text for self-study purposes. This and other potential solutions to the problems encountered in the Reaction Environment tables need to be evaluated from the programming point of view.

Evaluation

By working with the ORGSYN module, students obtained a thorough understanding of the Retrosynthetic Analysis concept. Since this concept was also used in classroom discussions of more complicated molecules, the learning experience in ORGSYN was reinforced (Fig. 9, quote 1). As a result, students developed confidence and elaborated more skilful and imaginative synthetic routes to target molecules posed in regular assignments. ORGSYN had an equally major impact in demonstrating weaknesses in knowledge concerning the Reaction Environment (Fig. 9, quotes 2 and 3). Students became acutely aware of the necessity for judicious choice of conditions in organic transformations.

Fig. 9 STUDENT RESPONSE

1. "... Practice in retrosynthetic chemistry was valuable."
2. "The most important thing I learned was that I was very weak in my knowledge of reaction conditions."
3. "All these years I have ignored solvent and temperature... some organic books do not bother to give conditions....."
4. "It gave me time to work out in my mind what was happening as opposed to the classroom where the information comes thick and fast."
5. "A relatively painless way of learning."

What of the interaction with the computer? Several students responded that it was better than a classroom tutorial allowing greater problem-solving time (Fig. 9, quote 4). Interaction with the instructor was judged to significantly increase progress through a given synthesis. As discussed in the Results and Discussion section, a large part of the human assistance could in theory be programmed. Finally, there appeared to be a definite improvement in learning ability using ORGSYN compared to the classroom. For example, in a normal assignment students failed to recall the function of a particular reagent after it had been mentioned several times in the classroom; yet having been exposed to it once in ORGSYN, the reagent was used correctly in subsequent problem sets. Quote 5, Fig. 9 is a possible explanation for these observations.

Conclusion

The ORGSYN computer-assisted organic synthesis module is successful in meeting objectives 1-3 (Fig. 3). Objectives 4 and 5 have not been adequately tested but may be tentatively answered in the positive on the basis of the student feedback. Due to time limitations, we have not addressed ourselves to objective 6, listed in Fig. 3.

With the initial exposure to the ORGSYN module, the student becomes a more critical and rational analyst, capable of designing organic syntheses of some complexity. ORGSYN should be useful as supplement to lectures and for remedial purposes at several levels of undergraduate organic chemistry instruction.

Acknowledgements

I express my gratitude to John Moore and Jerry Bolce for their patient efforts in overcoming the communication barrier.

References:

[1] A portion of this work is extracted from the M.Sc. thesis of J.A. Oakleaf, University of Waterloo, 1977.

[2] E.J. Corey, Quat. Rev. Chem. Soc., 25, 455 (1971); see also H.W. Orf, J. Chem. Educ., 52, 464 (1975).

[3] S.G. Smith and R. Chabay, J. Chem. Educ., 54, 688 (1977).

[4] H.L. Gelernter et al., Science, 197, 1041 (1977).

AN APPLICATION OF COMPUTERIZED INSTRUCTIONAL TELEVISION IN BIOLOGY

by

Bryce Kendrick

Professor

Department of Biology

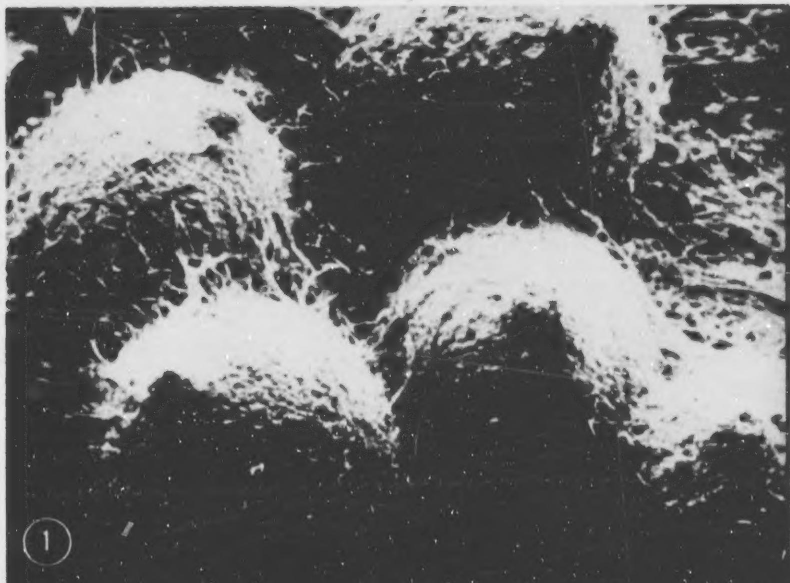
Abstract: The Fungi (like so many other groups of living organisms) are very unfamiliar to most undergraduates, and any course introducing students to the 100,000 or more extant fungi is immeasurably assisted and enriched by a variety of visual aids, particularly colour transparencies of macroscopic and microscopic phenomena. Computerized instructional television incorporated these into an interactive, self-testing teaching programme. However, students did not find even this sophisticated hardware an adequate substitute for the lecture experience and, much to the relief of their real, live professor, ultimately gave him a strong vote of confidence.

As a biologist who has always entertained a friendly curiosity about computers, I have on many occasions approached these strange creatures closely, and have sometimes succumbed to the siren songs of their keepers. Let us, they croon seductively, take care of all your chores. Let us free you to pursue your creative trains of thought. Trains that are so often derailed by the sheer oppressive tedium of storing, retrieving and sorting data; inevitable accompaniments as these processes are to so much scientific research.

It has not escaped me that, having fallen for the advertising, I have usually been transformed from a freewheeling biologist into a slave of the numbers, feeding the insatiable machine its approved diet. The promised freedom soon assumes a new guise -- that of a very small light at the end of a very long tunnel.

Despite repeated disillusionments of this nature, which thoroughly convinced me that computer inputting devices left much to be desired, I persisted in my attempts to establish communication with the C.P.U. At various times I have dabbled in numerical taxonomy, interactive computer graphics identification keys, computer simulation of biological processes, and establishment of an extensive biogeographic databank.

When COMIT was announced, it occurred to me that the computer owed me a favour after all the support and employment I had given it over the years. Computer-assisted teaching! Here was my opportunity to get some long-delayed return on my investment. The picture looked very rosy: colour television with a sonic pen facility as part of a flexible, interactive teaching programme. With a mixture of fascination and trepidation, I agreed to take part. I elected to use COMIT to introduce my students to a very numerous and diverse group of fungi, the Ascomycetes. These organisms are doubtless as unfamiliar to most of my readers as they were to my second year students when they entered course Biology 232 (Fungi and non-vascular plants). One of the major difficulties I encounter in teaching this course is that the students have almost no idea what most of these organisms look like or how they operate. One of my principal aims is to remove that particular roadblock. To this end I make liberal use of visual aids such as colour transparencies and movies. Figures 1-4 show the kind of thing I mean. Most rotten tree trunks have Ascomycetes fruiting on them, but how many people would recognize the very characteristic fruiting bodies of these fungi? Fig. 1 (actually a scanning electronmicrograph) shows what the perithecia of one wood-inhabiting Ascomycete look like under the dissecting microscope. Note their almost spherical shape and the short beak through which they expel their spores. Fig. 2 shows what you see if you mount a ripe perithecium on a glass microscope slide and squash it under a coverslip. The spores are held in rows of eight by a thin, colourless sheath which is the ascus -- the microscopic structure from which the Ascomycetes get their name. Fig. 3 shows a good collection of one of the most delicious edible fungi, the morel, which happens to be an Ascomycete. Figure 4 shows the unique appearance of a tiny bit of the inside of a truffle -- the gourmet's delight -- another Ascomycete. Here I can point out that the ascus is more or less spherical and contains only 1, 2, or 3 ascospores, which have a thick, ornamented wall. This helps them withstand passage through the gut of mammals which detect ripe truffles by their odour, dig them up and eat them, and subsequently void the spores elsewhere. By means of one of the best of all baits -- olfactory and gastronomic pleasure -- the fungus has used the mammal as a means of dispersing its ascospores.



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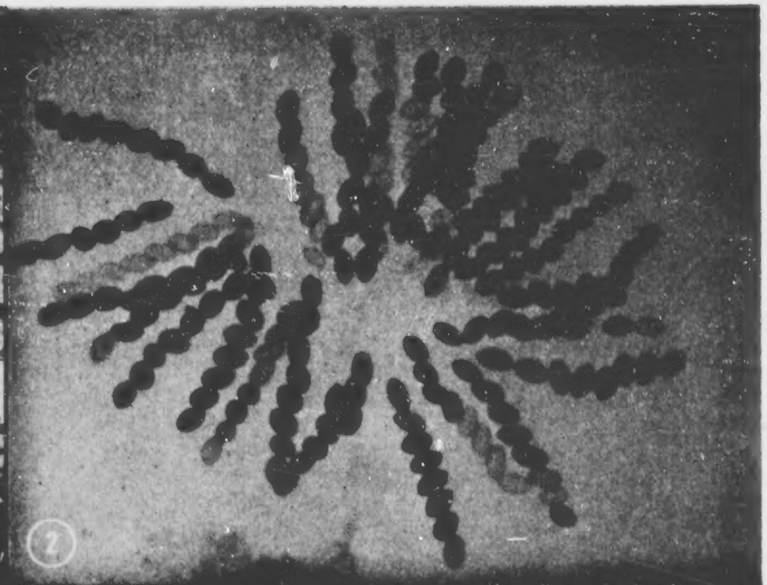

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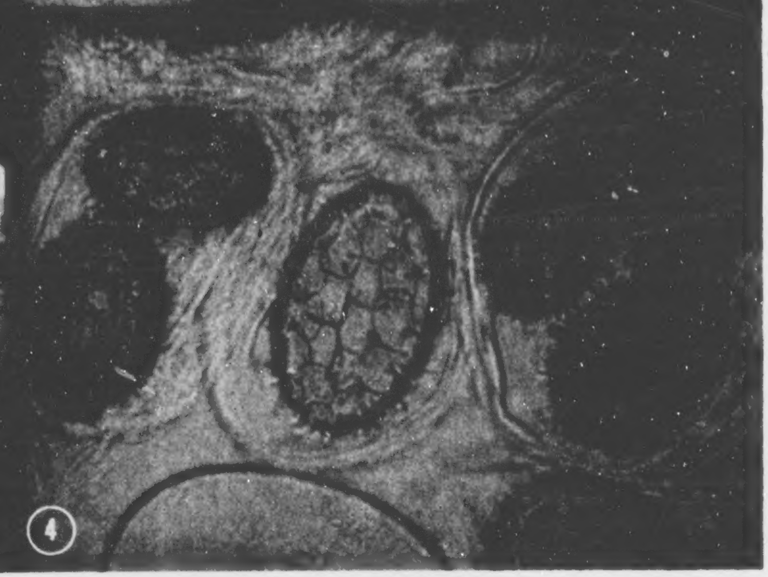


④

I hope these few examples have convinced you of the great importance of visual aids to the teaching of mycology. COMIT promised to make this material available in an automated, interactive system.

After some initial planning sessions, during which the aims of my segment were enunciated, we began to build the framework. I found that many diagrams I usually draw on the blackboard had to be produced as colour transparencies for COMIT. This was a plus, because I was subsequently able to use some of these diagrams in a correspondence version of Biology 232. But I soon became horrified by the massive investment of time which the production of this segment was obviously going to entail. I did not keep a record of the hours I spent on it, but I know their number was excessive. The parallel investment of time on the part of the COMIT programmer was, I know, larger by an order of magnitude than my own. After a protracted period of development during which innumerable changes and corrections had to be made, the system became operational, at least in theory. Another problem surfaced at this point. The computer had to be programmed to cope with all possible incorrect answers, as well as with essentially correct answers which had been misspelled. This called for additional hours of programming and consultations. After a further extended period of fine-tuning, it became possible to sit at the console and run through the module.

I had originally requested that a sound-track be incorporated in the module. I didn't press the matter too hard, and in the event, the sound track did not materialize.

I regretted this omission, because I believe that the information I try to present is better accepted when received by more than one of the senses. The mycology module in its final form was entirely visual. The students have to stare at a T/V screen, at very close range, for an hour or more. This probably bothered them far less than it did me, since they have been exposed to T/V from birth.

Because of certain unavoidable delays in putting the final touches to the COMIT module, the topic had already been covered in the regular lecture format when the time came for 20 volunteers from among the one hundred second year students to do the modules. I announced that there would be a class test on the topic the following week. This gave non-COMIT students a chance to revise the topic from their regular text and other materials.

The test showed that although scores of the students taking the COMIT module were, on average, slightly higher than those of the rest of the class, the difference was not significant.

I asked for written comments from the COMIT students. Since the COMIT module was a new toy, I was not quite sure how these comments would reflect on my regular presentations. I need not have worried. Their general tenor was reassuring. Many students claimed to have enjoyed the module, and to have found it a good method of revising material, but most of them also insisted that it could not replace the normal lectures.

But perhaps I should let the students speak for themselves. Here are some representative comments:
"... an excellent attempt at using sophisticated technology as a teaching aid ..." "... it was very well organized ..." "I look forward to using teaching aids of this sort (and this quality) in the future ..." "... you were able to go at your own speed ..." "... served as an excellent review ..." "... I intend to use the computer as a way to review for the exam ..." "... it was very effective in reinforcing the basic characteristics of the Ascomycetes due to the immediacy of interacting with the computer, and the thoughtful manner in which the segment was organized and illustrated..." "As a supplement to lectures it was worthwhile. It helped to clarify and condense the lecture material.... It was a good idea to involve the students in answering questions: since I was receiving immediate feedback, I felt like I was getting personal attention .. but if there was something I didn't understand, I couldn't ask the computer to explain. The slides were good, although not as clear as when projected..." "... You were unable to return to a previous part of the module if you found you had not grasped the concept fully..." "Even with the questions the computer is much like reading a text-book..." "... Perhaps if a sound track had been provided, it would have helped..." "... the lack of an audio stimulus made it perhaps a little boring..." "...Though the computer method was interesting enough, I felt I preferred the lectures and slides..." "... The programme was very impersonal ... the colours on the screen were often very bright, and after reading it for two hours your eyes became very tired ... lectures are preferable..." "... A good professor brings a lot more to a course than this pro-

gramme did. He brings interesting anecdotes, vitality, living proof that somebody really studies all this stuff, as well as a lot of humanism that the computer didn't have...."

My own feelings after the experiment can be expressed as follows:

(1) I now realize very clearly that it would be enormously expensive in hardware, software and labour, for computer instruction to replace even one professor for one course.

(2) Perhaps even more importantly, there is still no substitute for the human element in teaching. A good professor can communicate enthusiasm in a way that any computer would find difficult to emulate. In addition, the professor can immediately handle all kinds of red herrings, offbeat but interesting questions and backtrackings, and he can respond to the mood of a class or individual in a more flexible way than is possible even for the most elaborately programmed machine. (This is not to say that he always does!)

My general conclusion is that computer assisted instruction can be a useful additional resource, but that it is not yet time for the professor to quit the classroom forever. Only internal motivation can make a student learn and retain information and ideas. I believe he is still most likely to contract that motivation from another human being.

THE POTENTIAL USE OF COMIT IN THE STUDY OF HUMAN MOVEMENT

by
David A. Winter
Professor
Department of Kinesiology

Abstract: Two undergraduate student projects were undertaken on COMIT aimed at presenting many variables associated with human gait. The goals were to display the outline of the leg along with other diagnostic variables such as muscle activity (EMG), kinematic, kinetic and energy calculations. The projects were partially successful in demonstrating possible potential of the COMIT system as a teaching and diagnostic tool.

Introduction:

A complete analytical description of one stride of gait requires twenty or more time domain plots. These would include time histories of kinematics (trajectories of mass centres, angular velocities of limb segments, accelerations of joints, etc.), kinetics (reaction forces at the ground and between the joints, muscle moments, gravitational forces, etc.), energetics (potential and kinetic energies of segments, energy generation and absorption by muscles, etc.) and muscle activity (as indicated by its electromyogram). It is an extremely difficult problem to assess the interaction of a fraction of these variables in normal gait, and even more complex to integrate them to assess pathological locomotion. It therefore appeared that COMIT had the potential of presenting an integrated picture of many of these variables and of seeing their influence in time.

Student Projects

Two senior undergraduate research projects were directed to the development of user programs for the assessment of human gait. Data routinely obtained from the Gait Analysis Laboratory in the Department of Kinesiology were used. The aim of the two projects was the same: to present to the user a flexible display with which he could interact and see the "cause and effect" of the forces and muscle activity acting in gait.

The difference in the projects was in the mode of data entry. The first was given the coordinates of each limb segment from which a "stick" diagram of the leg could be generated to represent the body position every 33 ms. An algorithm was then used to generate the contour of the leg at each position. The second approach was to generate the leg and muscle outlines via a light pen tracing of the cine frame image as seen on the COMIT terminal. Once the leg outline was generated, by either technique, the outline of the major muscle groups was generated and their activity was presented two different ways: a 32 intensity level colour code was used to grade activity from 0 to 100%, or the % activity could be written alongside each muscle. The user could then call up the leg outline for any point in the gait cycle, insert the muscle activity and then examine the position of the limb at successive points in time to see the effect of the muscle activity. A second aim was to display quantitative measures such as reaction force vectors, energy levels, etc.

Success of Projects

The first goal, as described, was achieved successfully, but with some limitations to the user. The turn around time between instructions and display was sometimes delayed so it was difficult to assess rapidly changing events. The second aim was not attempted because of the time and effort required to achieve the first goal.

A logistic problem that severely limited the potential of COMIT was the use of cine film as a data base. There was no ready way to convert the cine data to TV so that it could be displayed on the COMIT terminals.

Conclusions

The project was successful to the extent that it demonstrated a potentially valuable area for the COMIT system. A considerable amount of additional programming was necessary to realize a properly interactive system that was useful for teaching and clinical diagnosis.

COMIT ICE HOCKEY PRACTICE

by

Robert C. McKillop

Varsity Hockey Coach

Department of Athletics

Abstract: Computer Ice Hockey practice was developed at the University of Waterloo in order to present the coach's systems to the players in a much more controlled academic setting than is available during practice on the ice. The objectives of the computer practice were: to allow players time to think about the systems and discuss alternatives with the coach; to give the coach a documented evaluation of how well the players knew the material; and to enable new material to be thoroughly taught and understood before going on the ice.

The results of this project were very encouraging to the University of Waterloo Hockey team players and coach. The idea is definitely a valuable one which could be adopted in many other sports as well.

In recent years, coaching the game of ice hockey has taken a very noticeable change towards a much more structured game. This attitude has been given a great deal of credibility with the emergence of such people as Fred Shero, Bob Pulford and Roger Neilson in the ranks of NHL coaches. These men all believe very strongly in a disciplined "system" approach to hockey where all players have basic responsibilities in almost all situations that may arise.

When a coach attempts to implement these systems, he finds that he requires much more ice time than was used in the traditional approach. The availability of ice time is at a premium in almost all locations. This has forced coaches into many alternative methods of presenting their material to their teams and led to the development of the hockey coaching module using COMIT at the University of Waterloo.

This COMIT module was capable of reproducing the various ice hockey systems in a manner that allowed players of the University of Waterloo Varsity Hockey Team to view them and to respond to a series of questions based on specific assignments designated by the coach. The program was designed to allow each player maximum time to study the systems in question and also to provide the coach with a detailed print-out of the player's responses to the questions he answered.

There are many advantages of having a program of this nature available to a hockey team. Valuable ice time was not wasted in a time-consuming teaching process of the system. Players were taught using a blackboard and then tested on the computer. The players had an unlimited time period in which to study and respond to questions. This allowed each player to study the problem thoroughly at his own speed before having to respond. The positions of all of the players of both teams were readily visible on the screen and he could see a complete system in one look, something he can not see or perhaps even comprehend while on the ice. The system allowed the player to make one incorrect response to each question before showing him the correct response. This feature meant that the player had to think out his replies based on the knowledge of the previous wrong answer.

The author was responsible for putting all the hockey technical data on the computer. Dr. Moore and his computer associates spent countless hours developing the computer program required, so that all the various systems could be included. The player sat down at the terminal and introduced himself by typing his name on a conventional typewriter keyboard. The player was then asked what position he wanted to study. Upon replying, the player was then asked what area he wanted to study. He had the following choices:

a) forechecking
b) backchecking
c) breakout patterns
d) power plays
e) penalty killing
f) miscellaneous - face-off
  - special plays
g) all of the above

When the player indicated what area or areas he wanted to study, he was then presented with a plan view of the rink on the screen as shown in the Figures. The set-up on the screen showed the player the formation with the offense in one colour and the defense in another. The position he was studying then began to blink (on and off) on the screen so the player knew exactly where he was on the ice surface. The question would then appear on the screen at the side of the rink outline. The player then had to point with a light pen to the place on the screen where he thought he should move. If he was correct, an exit statement appeared along with all of the other players' correct movements so that the player could see his movements in relation to his team-mates' moves. If he was incorrect, he would be told so and asked to try again. If he then succeeded, the above (correct) display would follow. If he was again incorrect, the player would be told so and then the correct movements would appear. The player could study the screen for as long as he wanted; when he was ready to proceed, he simply pressed "enter" and the next step would confront him. This procedure was followed for all questions in all systems. When the player was finished, a record then appeared on the screen. This showed his responses to each question, whether right, wrong or skipped, and then a percentage right and wrong for all questions.

This record was also available to the coach in the form of a print-out. The print-out told the coach who had taken part in the program, and how well he had done in each area. This turned out to be a very valuable asset to the coach. After the player had completed the test on his own position, he was then encouraged to try the tests for all the other team positions as well.

The players could attend the program at any free period during the day and could make very constructive use of free time.

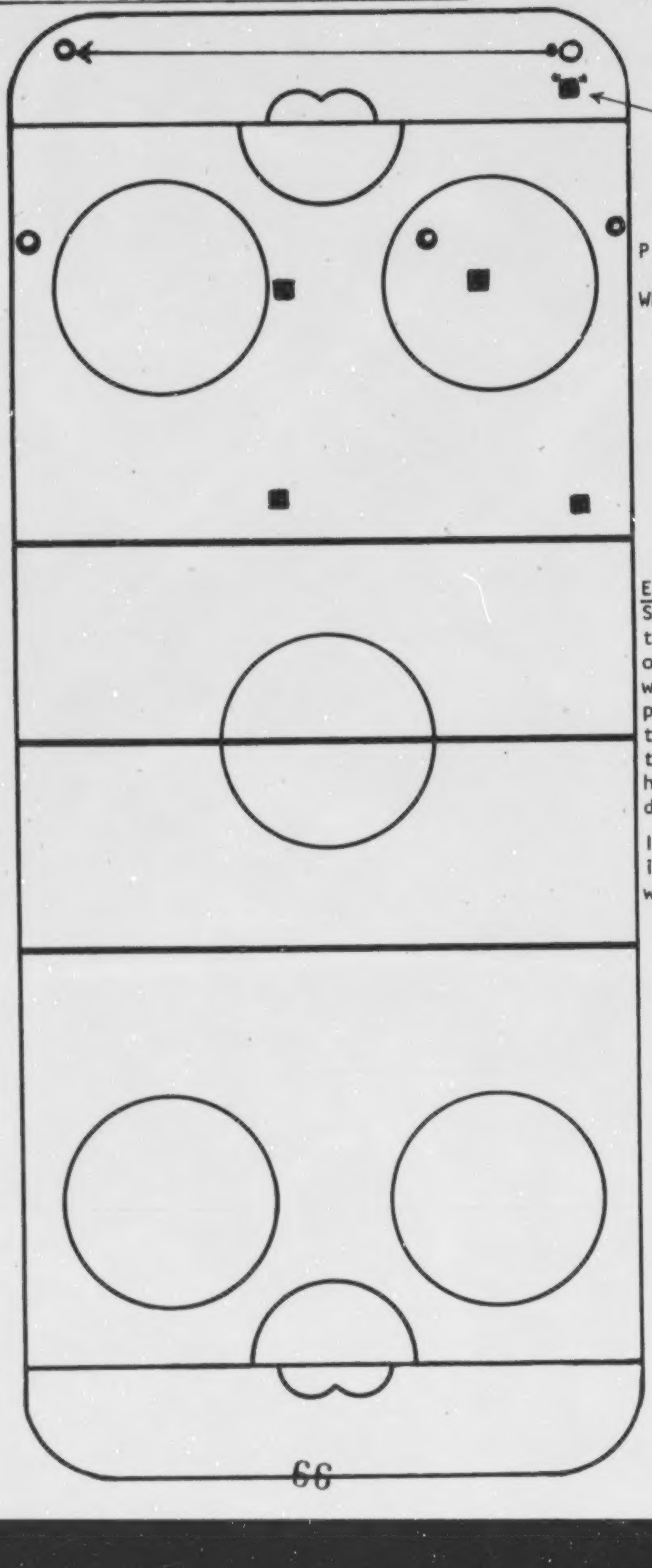
The results of this project were very encouraging. All the basic objectives were met and then some. It was found that the players could easily operate the program and did not feel out of place with it. The program initiated a great deal of discussion between the players and the coach. Usually this was precipitated by incorrect responses to various questions. This type of dialogue is often very difficult to initiate in a normal practice or game setting and turned out to be a major positive aspect of the entire program. The fact that players had to come up with specific answers to each question thoroughly tested their knowledge of the various systems and supplied the coach with these results. The resulting discussion made the players much more aware of all the systems and thus made the hockey club a better team.

When the players were introduced to this sytem, the team's league record was 0 wins and 7 losses after competing against teams that were not the class of the league. In the next 13 games, the team won 7 games and tied 2 against much superior competition. This result, in the opinion of the coach and the players, was due in a large part to the team being exposed to this computer hockey practice.

The only major negative comment that can be associated with this project was the tremendous amount of time required to get the system operational. This would be drastically reduced in any future project due to the groundwork laid in this endeavour.

The author wishes to express his sincere appreciation to Dr. J.B. Moore and his associates for their untiring work in developing the system so that the University of Waterloo Warrior Hockey team could take part in this project.

Fig. 1: Sample of What Player Would see on the Screen:



(RW Position Blinking)

Question
QFC1

Playing RW

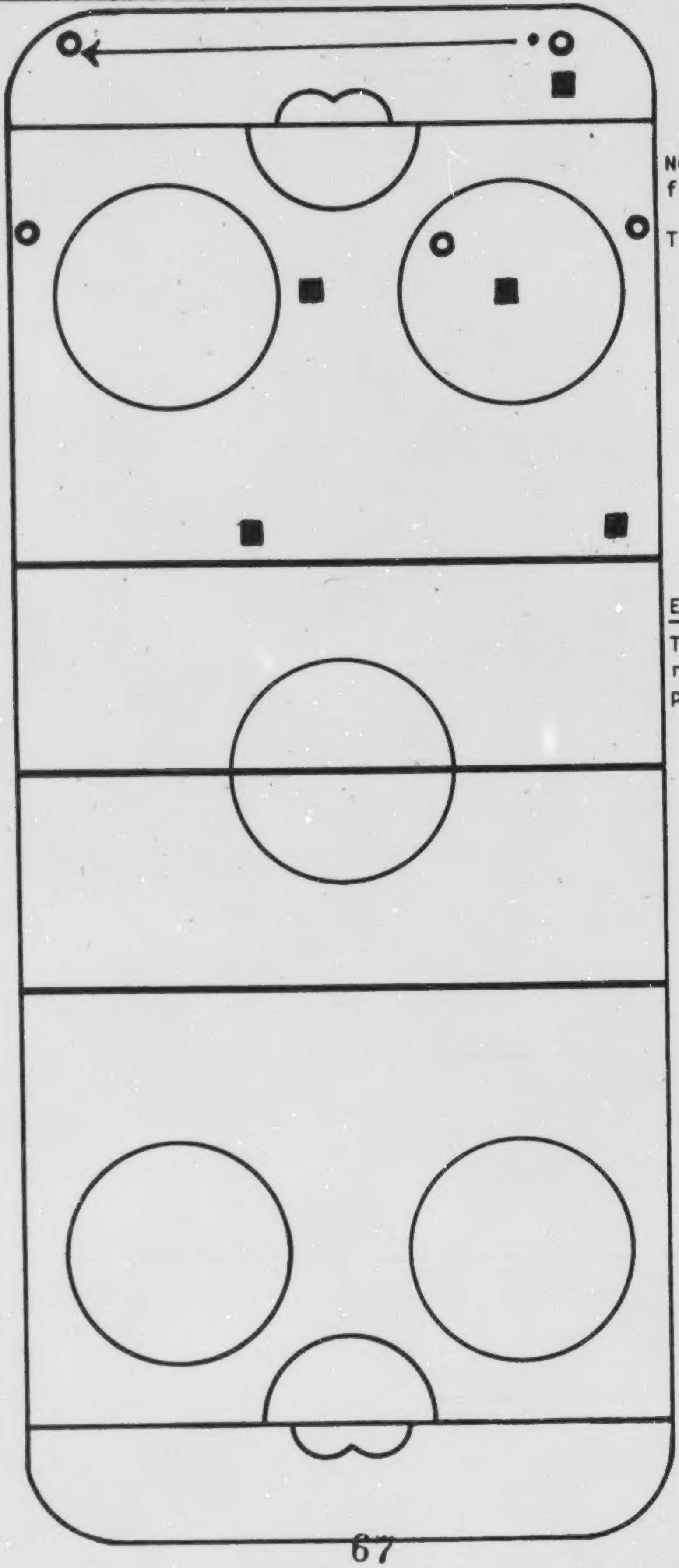
Where should you go?

Explanation:
Seeing the question with the RW position blinking on and off, the Player would now take the light pen and indicate where he thinks he should go, now that the puck has gone behind the net to the other defenceman.

If the player responded incorrectly the following would appear.

Fig 2: If Player Points to Wrong Place on the Screen:

Question
QFC1



NO. Must always force from the front.

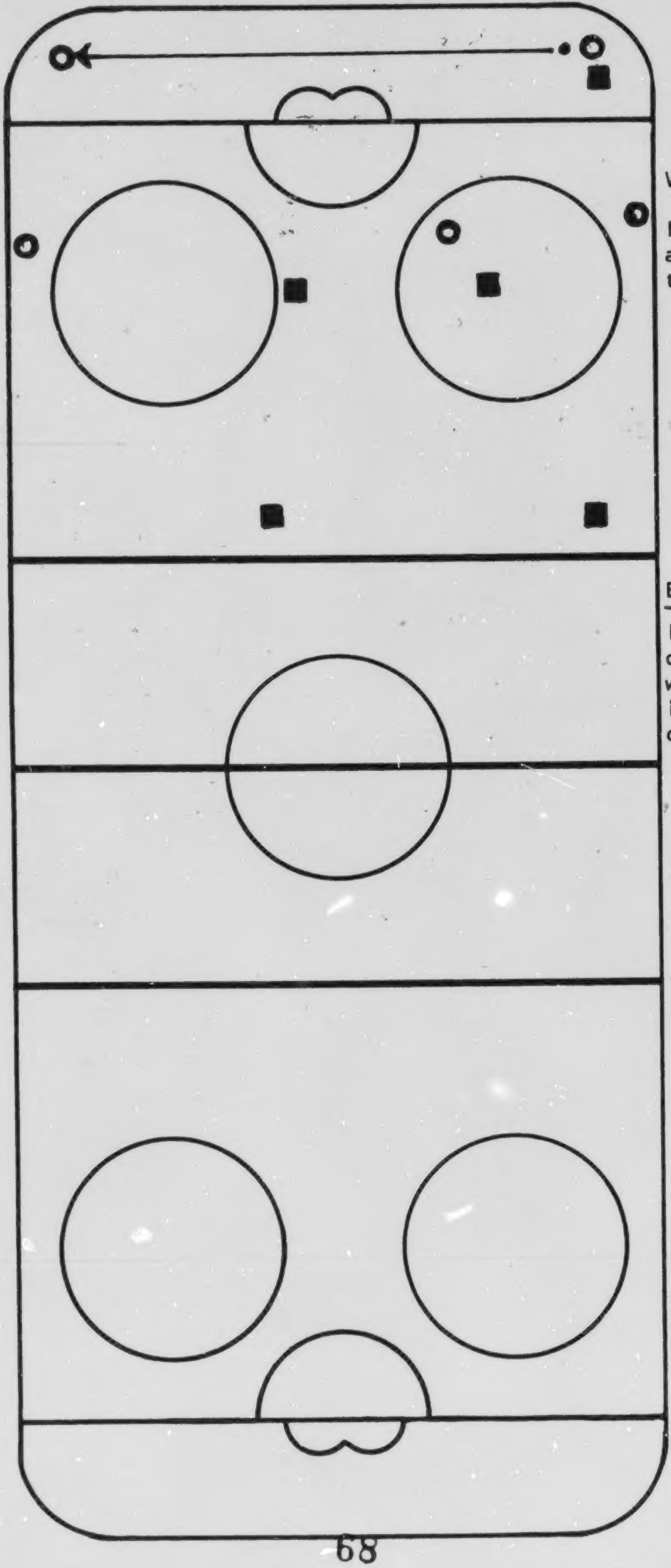
Try again.

Explanation:

The player would now repeat the original process.

Fig. 3: If Player Points to Correct Place on the Screen:

Question
QFC1



Very good.

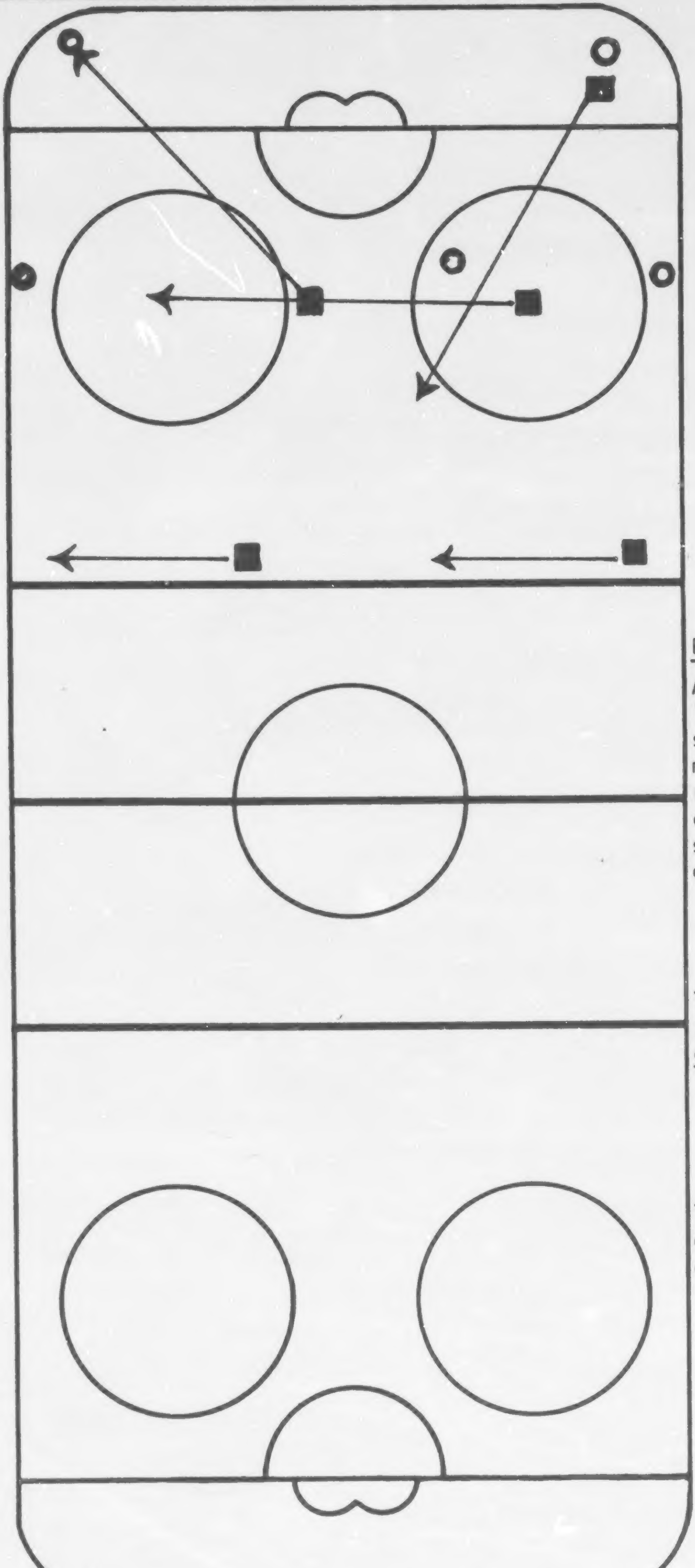
In forechecking we always want to force from the front.

Explanation:

If the player answers the question correctly he would then be shown what is indicated on this diagram.

Fig. 4: Correct Movements of All Players are then Shown:

Question
QFC1



Explanation:

After answering correctly on the first or second attempt or after making an incorrect response twice, then the correct movements would show as indicated on the diagram.

The player would then be told "When ready, press enter to proceed".

This procedure was repeated for each position in each question.

COMIT FOOTBALL MODULE
A SYSTEMATIZED STUDY OF OFFENSIVE LINE PLAY

by
Wallace A. Delahey
Assistant Director of Athletics
and
Head Football Coach
Department of Athletics

Abstract: In preparation for the football season, the team members must learn the many offensive plays, some of which are fairly intricate and therefore difficult to learn. To assist, a COMIT module was developed. The purpose of this project was threefold:

1) to establish a program of study for offensive line play in football for a variety of defenses,
2) to study the effectiveness of on-field teaching methodology as it relates to the retention of knowledge,
3) to study response time improvement.

As a result of the study, all objectives were achieved:

1) a program was projected which allowed each participant to identify his area of responsibility as it pertained to a specific play for a variety of defenses,
2) a definite increase of knowledge was shown,
3) a definite improvement in response time was demonstrated.

Introduction:

The football module included all offensive line positions (centre, guard, tackle and tight end) and showed their blocking assignments for a variety of defenses. Prior to utilizing the system, each player was provided a playbook containing all the information which would appear on the system and was also subjected to on-field teaching and training for a period of one week, with regard to the subject matter.

Methodology:

The program was divided into three phases:

Phase I : General Organization Regarding the Total Offense
Phase II : Specific Organization Regarding Offensive Line Play
Phase III: Game Play Components

Each Phase contained a number of questions directly related to our offensive structure and appeared on the screen as follows:

Phase I: General Organization Regarding the Total Offense

This section contained questions pertaining to the entire offensive structure, i.e. number of formations, number of series, number of plays etc.

Example:

1) How many Formations does our offense consist of?
   a) 6 b) 8 c) 10 d) 12
2) All Formations are considered as:
   a) balanced b) unbalanced c) a combination of (a) and (b)
3) Indicate which Formation is our Basic Formation:
   a) Power I b) Pro Set c) I Slot d) I Flank e) I Triple
4) How many Series does our offense consist of?
5) Please match the Series Name on the right with the Series Number on the left:
   1) 10
   2) 20
   3) 30
   4) 40
   5) 50
   6) 60
   7) 70
   8) 80
   9) 90

   a) Quick
   b) Power
   c) Short Yardage
   d) Iso-Tandem
   e) Sweep
   f) Pitch

Phase II: Specific Organization Regarding Line Play Only

This section contained questions pertaining to the entire offensive line and dealt specifically with the blocking rules by series and terminology application.

Example:

Under the following headings,list the order of priority of your blocking assignments with regard to each series:

A) Power Series:
   i) Gap ii) On iii) Check and Release iv) Near Linebacker
B) Quick Series:
   i) Gap ii) On iii) Near Linebacker iv) Check and Release

C) Tandem, Iso, Sweep and Pitch Series were dealt with in the same manner.

D) When referring to Trap Blocking it means a lineman will: i) Gap Block ii) Seal Block iii) Pull Block iv) Double Team Block.

E) When referring to Cross Blocking it means a lineman will: i) Fire Out ii) Pull Around the End iii) Exchange Responsibilities with a Teammate iv) Pass Block.

Phase III: Game Play Components (Player Specific)

This section identified a number of actual plays versus a specific defense (4-4, 4-3, 5-2, 4-5, etc.) and questioned the user (centre, tackle, tight end) as to the pertinent block in accordance to the area of his responsibility.

Example:

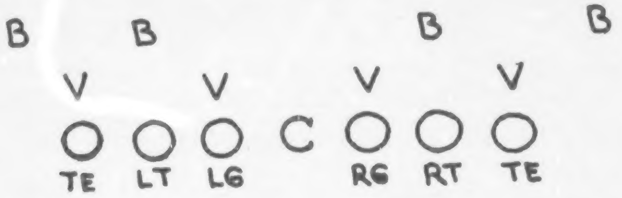
Phase III occurred during the week prior to each of our games. Due to the fact we knew in advance our opponent's defense, each offensive lineman was then quizzed regarding his specific blocking assignment with regard to the play called versus the selected defense.

Thus he would see on the screen:

a) the play call, i.e., twelve Full Back Power

b) the opponent's defense and

c) the offensive position, as shown below:



As, for example, the Right Guard, he would be required to indicate his blocking assignment (based on his priorized rules of blocking). In this instance, the man opposite (or "on" him) is his assigned blocking. For a correct response, the image touched would be highlighted.

Phase III contained the entire offensive running game, consisting of 30 plays. Each play appeared on the module versus the defense which we anticipated our opponents would utilize during the season. Defenses diagramed included: 4-3, 4-4 regular, 4-4 stack, 4-5, 5-2, 5-2 gap, 6-2, and gap 8.

Consequently, at any time throughout the season, the user could study his assignment for each play versus any of the above named defenses.

Usage:

During pre-season camp, which consisted of three weeks, all participants attended two sessions per week where the study encouraged responses to Phases I and II.

Prior to each league contest the participants also attended two sessions per week and responded to questions in Phase III only.

Conclusions:

As a result of the study all our objectives were definitely achieved:

1) A program was projected for each position which allowed the participant to identify his area of responsibility as it pertained to a specific play versus a variety of defenses.
2) The system provided an excellent indicator as to the amount of knowledge accrued through on field training, as well as appraisal of teaching methods utilized.
3) A definite improvement in response time was demonstrated - i.e. through frequent examination the user demonstrated a marked improvement in response time. This simulated a game type situation where the player must think and react instantly.

The participants were extremely positive in their comments regarding the module. Comments referred to the provision of immediate confirmation, the availability of repetition, and the fact that they could proceed through the program at their own pace. Also, they were extremely proud when they projected an error free performance. As a result, this established an excellent attitudinal base which carried over to their on-field performance.

The only negative or limiting aspect of the program was the fact that COMIT was unable to project a moving target. Consequently, the user was viewing, in Phase III, a somewhat unrealistic situation.

In the final analysis, however, I firmly believe the COMIT system has very great potential for teaching aspects of football and perhaps many other sports. It would be an extremely challenging and rewarding experience to develop programs that would take into account all positions (both offensive and defensive) on a football team. Such programs could further be reinforced through the inclusion of actual film demonstrations of live game action and a subsequent study of questions and answers.

COMIT: THE LEISURE EXPERIENCE

by

E.M. Avedon and T.O. Stewart

Professor Research Associate

Department of Recreation

Instructors who teach introductory survey courses that accommodate two, three, or four hundred students attempt to automate as much of such courses as possible. Usually, all tests and examinations are designed for automatic marking, and assignments are designed for automated analysis where possible. When such courses are taught year after year, with only slight content modification to introduce new findings or points of view, routine procedures for the use of audio-visual materials and other teaching aids are standardized as well.

Dr. Avedon is an instructor who teaches such a course. When automated teaching was brought to his attention, he became interested for a number of reasons. Recreation 100 is an introductory survey course that examines the phenomenon of leisure from a range of disciplinary perspectives, such as history, anthropology, archeology, philosophy, religion, economics, sociology, political science, psychology, planning, geography, and others. He had been responsible for the course for the past six years. The course has been taught in a large lecture hall, in a three-hour block of time one night a week, over a term. Students are primarily in first year from many departments and faculties both at the University of Waterloo and at Wilfrid Laurier University. Less than 15% of the class are second to fourth-year students. A few students each year are non-degree students, auditors, graduate students engaged in make-up year studies, and part-time students.

The course is taught in typical lecture fashion, where the instructor functions as the primary medium of instruction. He makes considerable use of instructional aids, such as sound motion pictures, overhead projections, 35 mm slides, video tapes, audio tapes, charts, maps, and a variety of artifacts which are passed around in class. His intent in using different devices has been two-fold. People learn in different ways, and the range of media has been calculated to appeal to the differing learning abilities of students. Secondly, three hours of straight lecture is difficult for any one to sit through. The size of the class, and the amount of material that must be covered during the term limits the amount of discussion that can ensue at each session. Many students, particularly first-year students, are intimidated by the size of the class, and are afraid to ask questions or comment. Interest in automated teaching was also stimulated by student evaluations of the course. Each year students report that they wish there was more opportunity for individualized instruction. Students cite the desire for specific types of opportunities:

1. to have certain content presented at a slower pace;
2. to have some content repeated;
3. to have more time to "think through" certain concepts;
4. to be able to have various technical terms used in a lecture defined during the lecture;
5. to be able to examine certain diagrams, charts, or slides in more detail;
6. to participate in a structured tutorial experience that would highlight salient factors in a lecture;
7. to review certain content in considerable detail.

Our initial understanding of COMIT was that the proposed system could be used to meet some of the expressed individual needs of students that could not now be met with the classroom methods in use. The system would be designed to permit an individual student to experience a series of lectures in a manner similar to those presented in class; however, the student would be able to interact on an individual basis during any part of the lecture. The student would be able to proceed with the material at his or her own rate of speed, define technical terms as necessary, repeat sections of the lecture that were wanted for review, and engage in tutorial and summary-review sessions. Most of the audio-visual aids used in the classroom could also be used in the system, therefore, students using the COMIT system would have almost the same experience as those in the classroom.

The system sounded ideal, and seemed to offer many of the advantages that the students had been requesting.

On Becoming An Author:

Like others in the project, the first few weeks were spent learning how to become a "course author". We really didn't have a firm understanding of the total task at this time. Support and encouragement of the Department of Recreation chairman and other members of the Department had been expressed. The dean talked with Dr. Avedon about the project, and reminded him that once involved, some "tradeoffs" would have to be made;other activities that might be more significant might have to be sacrificed. We did not know (back in 1975) how much time would actually be required. In any event, we proceeded to become "course authors".

Since Dr. Avedon had been teaching the course for a time, his lecture notes were well organized (or so he thought). He began the "authoring" process with the assistance of a graduate student from the Department of Recreation. With COMIT staff, we decided to use the section of the course dealing with history and archeology. This section took about seven hours of lecture time in the classroom, and was usually followed by the first quiz. Readings that accompanied the lecture were from the first three chapters of the course textbook. We began by writing some tutorial statements and questions concerning the first topic - how historians and others know about daily life and leisure behaviour of preliterate society.

Sometimes Dr. Avedon would write a "frame", and sometimes the graduate student assistant would write one. After we had a few frames completed, we were shown how to enter them into the programme, and view these on our Volker-Craig terminal. We were very impressed with what we were doing, but still had little conception of what the total package would look like. COMIT staff had told us about the hardware to come, and were quite patient with our neophyte productions and our almost daily cries for assistance. As we began to put the frames together as a unit, it was noticed that the tutorial had begun to take on a personality of its own. We had tried to take the edge off some of the material through use of colloquial expressions in the "hint" messages, "wrong" answer messages, and "exit" messages associated with each frame . Subsequently, as each unit was developed, we made a conscious attempt to mold the personality of the automated tutor . Finally, we called him "MARVY"(short for"MARVELOUS"), We then went back over all completed content, and wrote and rewrote an introductory session in which MARVY introduced himself and explained to the user how he could be of help. This task forced us to gain more understanding how the system would work. We decided that we wanted the experience to be as personal as possible for the potential user, and we requested that COMIT staff modify the programme so that MARVY could refer to the prospective student user by name, not only in the introduction, but in rewarding the student user when a tutorial answer was correct.

This action, though contrary to most approaches to computing, was in concert with good pedagogic practice. The request required the COMIT staff to write special software for our course. After a while, it became apparent that the standard COMIT introduction and instructions for users were not in keeping with our MARVY concept, so we rewrote these materials as well.

During the process of building the tutorials, Dr. Avedon found that his course notes were not as adequate as he believed them to be. Some notes were detailed and explicit, while others were so terse and cryptic, that even he didn't know what he had intended. In some instances, the graduate student assistant would question his logic, and consequently he reworked his notes. Furthermore, the COMIT system forced a course author to anticipate certain types of responses from users, and to prepare messages accordingly. These two factors were instrumental in stimulating him to find a more adequate method of organizing notes, and to find additional detailed information for class lectures.

When we were satisfied that we had built the general model for the COMIT course, we enlisted the aid of a number of undergraduates who in the past had taken the course in the classroom. We asked them to test the tutorial on the Volker-Craig terminals. They provided us with suggestions for improvement of content. They told us when parts of the module were not clear, but most of all, they let us know that we were on the right track with the "tone" that we had built into the module.

Using Special Features:

When the tutorial sections were finished we found that we had about fifteen programme segments. We built the module in such a way as to provide a few minutes of the course *per se*, then tutorial content, then more course material, then more tutorial, etc. At a natural break in the content, say going from one period in history to the next, we provided a short summary. We then developed longer review sections. Next we created some software which offered the student the option of deciding if the summary was enough of a review, or if a more detailed review was required. If the student user went through the detailed review, he or she was then asked if that was enough of a review, and if not the subunit could be requested again and the student user could redo the session. During this time we also built a glossary of technical terms that could be requested by the student user at any time.

Our next task was choosing the visuals that would be used. The hardware had not arrived so we were not sure how the slides and overheads we used in class would look on the special COMIT terminals. However, we selected these materials and (with help) began to write software statements for their use in the module. Subsequently, when the COMIT terminals were made available and we got a look at some of the visuals, we found that they were not appropriate. In the classroom, a slide is "blown-up" on a screen and details can be readily observed, but on the terminal detail was often lost. This factor necessitated a search for more adequate visuals. This latter process acted as a catalyst to examining all of the visuals used in the classroom, and to effect change and improvement there as well.

Some standard slides and overheads just would not work well on the COMIT terminals. Consequently, we were introduced to the use of the colour-T.V. camera. The technique was new to Dr. Avedon. In the past he often found visual materials, a portion of which was appropriate for teaching purposes; but these had to be discarded because of some content present. The colour-T.V. camera enabled us to store on the video-disk only the portion of a visual that was relevant. This enhanced the module considerably, for as a result, within the COMIT project certain concepts could be illustrated that could not be illustrated in the classroom. We finally loaded about 250 visuals on the video-disk.

The next task was to create the audio tape portion of the module. If Dr. Avedon thought that he had problems with his course notes before, he must have been dreaming! Now he found that what was needed was a complete plan for recording purposes. His voice would come from a set of headphones while the student user was viewing a slide or some other visual, and we had to be sure that what he was saying matched the visual the student user saw on the terminal. At times other sound sources (such as he used in the classroom) were required to match visuals. He began to write a script in the true sense of the term. The process became more complicated as he went on since he had to indicate when audio would be used, when video would be used, when a visual would be on the screen, when a tutorial question would be used, etc. In addition, he had to include different indications for timing with respect to leaving space on the audio tape for a slide change, or a tutorial section. Fortunately, he was familiar with the UW software package SYSPUB and using this package simplified the process of writing the script.

This process also resulted in his decision to prepare all of his lecture notes for the entire course in the same manner, which resulted in another "payoff", that will be mentioned later in this paper.

After preparing the complete script, Dr. Avedon began the process of making the necessary audio tapes. Because of constraints placed upon the use of audio material by the hardware, nine different 30-minute tapes had to be recorded. Although he had access to recording equipment that could electronically mark each segment on the tapes, COMIT staff had to glue reflective markers before and after each segment of tape. There were about 200 of these, and four copies of each segment!

Next came the creation of video segments. These were done at the University of Waterloo Audio-Visual T.V. Studio by the audio-visual staff. Unfortunately the colour camera was not installed, and the video segments were made in black and white. On camera, Dr. Avedon went through the motions of giving portions of lectures in a classroom setting. He used the blackboard, and handled various related artifacts that were being discussed. In all we made about 20 video segments.

The next step was to transfer segments of motion picture film to video tape, and superimpose audio tape sound on the video tape. Dr. Avedon selected film segments and worked with the audio-visual staff in their studio to effect this process.

Putting It All Together:

Working with COMIT staff we "married" the various components together in the module. It was at this time that we were introduced to a number of other techniques that could be built into the system. Some map work with use of the light pen, and certain colour flashing effects with visuals had been planned to take full advantage of the COMIT system. These aspects were added at this stage. We also found in testing pieces of the module, that certain quoted material on audio tape could further be enhanced by showing the user the words on the terminal screen as the user heard them. Thus, we added this aspect to the module. We learned at this time about the system's ability to enlarge characters on the screen, and we modified certain content in this manner. When we had finished, the module was composed of the following components:

1. introductory material and user instructions
2. tutorial material

3. summary and review material
4. slides, photographs, diagrams, etc.
5. audio tapes
6. video tapes
7. motion pictures on video tape
8. textual material for visual display
9. light pen and other visual display effects.

If we were to do it all again, we would probably do many of the same things, but in a very different sequence. The new sequence would go something like this:

1. write the script
2. tape the video segments
3. tape the audio segments
4. choose the visuals
5. write the tutorials
6. write the summaries and review materials
7. add the visual enhancements.

The Student Users:

At first the plan seemed simple. About fifty students would be chosen to use the COMIT module instead of attending Recreation 100 in the classroom during the 1977 fall term. We had been told that a systematic evaluation would be conducted by someone else, and our department would not have to be concerned with this aspect. Subsequently, we learned that if we wanted a systematic evaluation, we would have to do it!

Dr. Avedon persuaded one of his research associates, Mr. T.O. Stewart to undertake this task. One group of 50 students from the class was chosen at random to take instruction from the COMIT module. For analysis purposes, a matched group of 50 students from the class was chosen to take instruction in the usual manner in the classroom. Matching was on the basis of gender, year of study, and department of registration. Both groups would then take the usual first classroom quiz as a normal part of the course to determine if there was a difference in the amount of information retained and whether this difference could be attributed to the method of instruction received.

A somewhat elaborate design was constructed that included a pretest device and a structured sampling procedure. The experiment ran during the first three weeks of the 1977 fall term as planned. Considerable data was gathered, and we are still in the process of analyses. However, at this time, we have been able to determine several things.

From the results of the pretest, it is clear that the two groups did not differ significantly in the amount of material they knew before they started the course. From the results of the posttest, a considerable increase in the amount of information acquired was achieved, but there was no significant difference between the two groups in the amount of information increase. A large number of exogenous factors were controlled for, and still no differences were found.

These preliminary findings may not sound important, depending upon one's frame of reference. These findings could be interpreted to mean:

1. Dr. Avedon is as good in a large classroom as the computer is in a one-to-one situation;
2. The computer can teach as well as Dr. Avedon can;
3. The computer did no better than Dr. Avedon;
4. The computer did no worse than Dr. Avedon;
5. Or we were measuring the wrong things!

Toward the end of the fall term, students who had used the COMIT module talked with other students in the class about their experience. Consequently, "the others" asked if they could try the module, especially as a review technique in preparation for the final examination. Some students who had missed some of the early sessions of the class asked if they could make up these sessions by using the COMIT module. We understand that a number of students scheduled a series of appointments for these purposes prior to the final examination period.

A Postscript:

Members of the Department of Recreation Curriculum Committee also spent some time testing the module and they wanted to know when they could start developing a course on the system as a consequence of their experience. They were rather disappointed when told the system was only experimental and would be leaving the University. As specialists concerned with leisure, and aware of the growing amounts of leisure used in North America for adult and continuing education, the COMIT project was of particular interest to members of the department. COMIT had been able to incorporate a standard televison set into its design, and this coupled with the growth of home computing, indicates that the project itself may be a glimpse of leisure behavior in the not-too-distant future.

Three other results are immediately apparent from the experience. The department curriculum committee has decided to make use of components developed for the project in a correspondence course to be offered this fall. Dr. Avedon's course notes cum script are now in such organized condition, that he has a draft of a manuscript for a publishable textbook. Finally, he looks forward to teaching the course this fall with all of the enhancements developed for the COMIT project. The project stimulated a number of new thoughts on better ways to teach the material, and he is going to try to include some of these methods this fall. We only wish the University were going to retain some of the software from the project to provide all the students with tutorial and review capability if not through the computerized instructional television then via standard UW hardware.

ITEM	DID	WOULD DO
write script	4	1
tape video	6	2
tape audio	5	3
choose visuals	2	4
write tutorials	1	5
write reviews	3	6
add enhancements	7	7

Figure: COMPARISON OF THE ORDER OF COMIT AUTHORING TASKS

COMIT AS A TEACHING TOOL FOR THE HISTORY OF ART

by

Eve Kliman
Assistant Professor
Department of Fine Arts

Abstract: This brief paper reviews our experience of COMIT for an introductory survey course on the History of Art and concludes that its useful application to the subject is relatively limited.

Fine Arts 111 is a course in the history of art which introduces students to the painting, sculpture and architecture of the Western world from ancient Greece to modern times. The course stresses the fact that works of art reflect the preoccupations of their epoch. Students are therefore expected to become familiar with the broad categories of style and meaning in Western art. They are required to recognize major works, to be able to place them historically, and to understand something of their particular meaning.

As an experiment we fed 200 slides into the computer terminals and arranged viewings for approximately 70 students. Some problems of reproduction immediately became evident. The terminals reproduce sculpture and architecture with an acceptable degree of accuracy; colour can remain close to monochrome and [illegible] details are not essential. Reproductions of paintings fare much worse, however; the proper colour balance is often impossible to achieve and the quality of the line suffers.

In general the students found it interesting and novel to use the terminals. There were inevitable frustrations, of course, some of them minor. The chief drawback I became aware of was that though the terminals had been scheduled for use, in practice there were a few occasions on which they were not available. Once the equipment had broken down; another time it was being overhauled. Even if such interruptions occur rarely, the fact that they can and do occur creates problems for the management of a course. The problem is insignificant as long as the slides are simply an optional enrichment. But if the students are to be tested on material included in the television presentation, even a single breakdown, in an inevitably tight schedule, creates some injustice and provokes a legitimate complaint.

For our purposes books, slides and good quality photographs provide us with simple, flexible tools for teaching. The terminals are unable to do justice to the subtleties of art, particularly of painting and they are somewhat rigid in the way they have to be used with large classes. Our conclusion therefore is that the COMIT project does not provide a workable addition to teaching methods in the Fine Arts department.

COMIT ENGLISH MODULE

by

Paul Beam
Associate Professor
Department of English

Abstract: Purpose of Module - The module is designed to teach analytic method to second year English students in a required course and it requires (depending on student's ability) between four and ten hours of study. It permits a more thorough presentation and review of the lesson than is presently available in any other form.

Structure of Module - The subject of the module is Analytic Criticism and involves four contexts - Linear, Setting, Imagery, Structure. Students may review within and across categories and seek additional information at any point in the lesson. Both voice recording and visual display combine to teach sequences of the lesson and the student is required to respond to points throughout; records are kept of all responses from keyboard and light pen.

Assessment - Throughout the lesson, student responses elicit author comments on the correctness and completeness of each response. Since all responses are recorded, the author can obtain a complete record of each student's performance. This data can be made available to the student for self-evaluation and provides a cummulative data base for subsequent authors to predict student performance. In addition, the COMIT module has some unique memory features which permit the author to check, for example, the time taken to respond or the sequence of answering questions.

Problems - technical, pedagogical and instructional - Response time by the unit is critical - it must be instantaneous, as fast as the student can write, draw or type. Failures here were my greatest frustrations. Next were difficulties in synchronizing audio and visual signals to link the two responses to student requests. Both of these are resolvable by changes in equipment. Results of student performance have been high in comparisons with control groups in conventional lecture/tutorial situations. Personal responses have varied between acute frustration over technical delays to strong feelings of accomplishment and an awareness of materials and methods more complete than any previous learning experience in isolation. Students have not been "isolated by the machine". The questions they now ask are academic responses to the work at a high level.

The COMIT English module uses most of the interrelated devices of sound, sonic pen, keyboard, slide and terminal display in a lesson which, depending on the student's interest and ability, may last from four to ten hours and which forms an integral part of our second-year course in critical analysis.

From the outset I sought to present a combination of a lesson, a test and a means of detailed assessment which would permit (or oblige) a student to learn more by his or her involvement in the lesson that I could provide in a similar period of classroom time. I hoped that the user would be able to examine in detail those areas which seemed to best offer insights into the methods of analysis and I planned to watch over the students' reactions and choices of direction using the whole range of the machine's ability to record, time and compare statistically the user's performance. Throughout the project I have regarded the module - the student's use and development of the material under the lesson's direction - as yet another extension of my teaching method. Over the years I have become increasingly aware of the advantages to students in selection of learning time, the ability to reuse lecture material for greater comprehension and review and the permanence of records which are present in the simple expedient of recorded lectures. The Correspondence Program further taught me the advantages of several new kinds of organization of individual lessons and of the whole pattern of a course. I was anxious to extend this into a more sophisticated lesson and COMIT offered this possibility.

Finally, class size and the kinds of unwarranted assumptions an instructor must make about "average" levels of training and preparation, the "average" number of illustrations one should use to walk between a class's boredom and confusion, the degree of "participation" one can permit in a contest with the clock and the reactions of the class as a whole - these questions made me seek answers in kinds of teaching over which the individual student had greater control and to which he or she was obliged to make many contributions. The idea of the student constructing the lesson with emphases on areas of best understanding at an optimum rate of progress seemed to be a good adjunct to my teaching in the course.

As in most disciplines, large areas of English lend themselves to facts and concepts - "genres" are categories of similar structures, "periods" presume similarities by chronological proximity. I tried to avoid these completely and chose instead part of a course in which two thirds of the students' year mark is derived from material which can be read orally in twenty minutes. The point of the course is to have readers become aware of the levels of meaning which function along with, but are distinguishable from, textual meaning - the level of grammar, vocabulary and the formal conventions of language. In effect, I must teach material and method in which internal relationships among words are at a premium and external details often have no importance - the name of an author, the date of composition, the edition, are often extraneous and detrimental to this kind of analysis. My question then became: "Is it possible to have the module provide a more complete and effective instruction in both these levels of meaning and in the techniques by which we come to see them than I can in a conventional lecture?"

I chose a passage which I knew well, in part because it had a wide applicability and a minimum of historical or social context. Another factor in my preparation was my increasing unease and annoyance that students would not admit - might not even be truly aware of - their unfamiliarity with the very basic concepts of language in which this area of study is based - questions of punctuation, vocabulary, and syntax in the ordering and sequence of words. The value of the course lies in their coming to see that the higher level of meaning, to which they are often subjectively sensitive, lies in their subconscious uncritical assimilation of these details; as they begin to understand that they can separate what they "feel" about a given piece of writing from what they can objectively demonstrate as being present in the work and accessible to all readers, why, then their critical souls stand up and are counted and they begin to function as students of language.

Now, this kind of insight arrives at different times, in different ways to the many different backgrounds and abilities present in each section. And the kinds and degrees of detail which an instructor can incorporate into a lesson can be guaranteed to bore some and confound others. For instance, under what circumstances is meaning altered by the use of a semicolon instead of a comma or, alternatively,a period, between two clauses? Like other answers, this can be important in determining meaning but it can also oblige me to waste the time of the majority of my class if I must explain it, or to help them learn little if I presume incorrectly that they know it. I can be sure if I ask publicly that they will deceive me. One of the strikingly simple functions the computer model offers is a glossary, accessed simply by typing the word or phrase of every item in the passage and in the teaching terminology of the lesson. The results have been that students have selected, in precisely the situation of their needing them most, all of the definitions of which they were unsure and about which they almost never would ask in class. Some hundred and twenty entries in the computer records contrast with only three similar requests in the lecture section by the control group in my most recent survey. As students request material not included in the glossary I can add it at my discretion and expand and correlate current material as it applies. A further application of this kind of information is as directives to individuals where a series of notes attached to an answer in vocabulary can direct the user to relate the definition specifically to other parts of the passage and lesson or to consider critical sources which treat the question in greater detail or in alternative ways - questions of connotation, etymology, and phonetics. The areas of expansion are as large as the instructor's imagination and the user's desire for information. None of these functions is available in the present option of a dictionary - a tool which students who require it most presume in any event a priori they have no need to consult.

The module has the facility in most of the areas of my conventional lesson to be both more complete and more specific to the student's request than I can be, certainly in class and often in a tutorial session as well. When users are content with some three meanings and four examples in a question of punctuation clearly set forth on the screen, they simply depress the "Return" key and proceed - an option they surely must have wished they had on past occasions when they asked me personally for this information.

Because the module does not have the kinds of time restraints of a fifty-minute class it never permits me the luxury of explaining that "I would like to be able to go into this subject in greater detail but it is 9:20 and another class requires the room." As an instructor I am obliged to both define the lesson and to then meet those definitions with a completeness that explains each part and connects the parts to each other in the whole; fortunately this also permits me to move more freely among, and make connections across, features like grammar and rhyme, the devices of imagery and the elaboration of setting, but I can make these effectively for each user as his or her responses indicate an understanding of them.

Inadequate responses elicit a suggestion from me to review the material, very poor responses require it. Good and complete work receives a mechanical note of praise and, on occasion, the recommendation to further explore the topic in the library through appropriate readings. I would like to expand the function of incorporating particularly good student responses and insights at each level of the work; this would hardly constitute "discussion" in the classroom sense of the word but it represents Arnold's meaning of "the best that has been thought and said" more accurately than the dialogue in class which promises so much at the outset but which then goes on to illustrate the outer fringes of the tangential and the banal. If the module lacks the spontaneity of in-class discussion, it retains control of the quality of student response and can show at every stage edited examples of fine student work.

The machine's capacity to retain these responses accurately in forms and lengths of the instructor's choosing and to present them as each student shows a need or a desire to consider them is a clear advantage over my less than total teaching recall, no matter how familiar I am with all aspects of the work in hand.

Some of my best results have come from users' involvement in the lesson. In fact, "lesson" with its connotations of someone showing someone else how to understand or to perform certain functions, is a slightly misleading term. In this case the student is presented with an unpunctuated, unspaced version of the passage and is asked to reconstruct it into a form which is optimally comprehensible to a second reader. The student, in effect, comes to know the passage by his or her own best efforts and I have the added advantages of their coming to see for themselves that formal devices like "rhyme" or "stanza" not only do not function, but are not even present, unless they are perceived by the reader. From the most basic devices of vocabulary, grammar and punctuation it is possible to demonstrate, by the student's reconstruction, that "meaning" is a complex interrelationship of separable, definable parts and it is possible to do so by having each individual construct that meaning by the rules which govern the particular categories within which he or she is working. A copy of the passage in its final, punctuated form is included at the end of this paper.

To illustrate, at the level of vocabulary, the student is asked simple comprehension questions at the outset. Is one aware of location of setting, times of day and season, objects and creatures referred to in the passage?" Responses in each category span the obvious to the complex so that everyone notes the terms "winter" and "thorn"; fewer list "lawn" and only the best perceive that leaves, to be seen as green, require the brightness of sunlight in daytime. The game is simple enough and the sonic touch pen, with the capacity to modify and delete as well, is an accurate and direct way of indicating an answer and having it appear on the record. The ability to have one's answers checked by the instructor's selections appearing immediately on the screen on request, in a contrasting colour, is a decided advantage to either the student waiting to see my answers before thinking about the question or waiting until I have an opportunity to mark and return work in a later class and a different context. I grant that the student loses the advantage in many cases of being able to ask immediately why I regarded a certain response as incorrect but to compensate I can provide a prerecorded explanation of each of my selections so that a touch of the pen to any of my answers elicits a statement (graphic, written and/or verbal) which expands on why I selected it and how it relates to the area of our study.

At this point permit me to note one of the frequent benefits to my conventional teaching from this kind of design. In a given teaching situation it would appear at first glance that the student responses and kinds of questions are as infinite as the imaginations which form them. Where I have been put to the necessity of tabulating these, I have discovered that the vast majority resolve themselves into several questions, a significant number of which can be anticipated and answered. In the case of this lesson, I had marked several hundred analyses and discussed them in regular classroom situations prior to ever asking students to consider them on the module. Genuinely new users' questions are infrequent and unanticipated responses almost never occur. When they do, by the capacity of the machine, I receive them and can answer them for subsequent use if they merit it and respond to the student in light of them at the earliest opportunity. In any event, the student's very request serves as a record for future use and as a constant form of check on a pedagogic structure which is thus improved in comprehensiveness and quality by use.

At the simpler levels of comprehension and grammar these interactions among machine, student and instructor are very direct and usually are brief and definitive. And it is on these apparently simple questions and the responses to them that the student gains confidence and a sense of a larger unity of meaning. Out of questions about times of day and man-made objects (five or seven? and the machine can be as flexible and reasonable as I am with as good reasons in matters of spelling, definitions or image patterns), I can illustrate the emergence of the complex, interrelated structures of setting and imagery and the unstated reader assumptions of a diffident sophisticated, intelligent narrator whose vocabulary, syntax and powers of expression intimidate the reader and convince you and me that we are content to listen to him without having to engage in an argument about a subject to which he refers on some thirteen occasions without ever naming - the question of his death.

But such a view emerges by degrees from some six hours of study, on average, and it emerges because the student is obliged to make the connections at all levels under the direction, by questions and statements, of the module.

Devices of colour and sequence, so that my answers compare in red and contrast in blue with student responses, of variations in tone of voice, across the speaker matched to visual displays by light emphasis to illustrate how intonation can alter meaning, of the student's options to review material immediately or request additional information, of the alteration and supplementing of audio and visual displays, of the masking and accentuating of contrasting parts of the passage,of the development in sequence or in degree of emphasis of image patterns and their influences on meaning, of the ability to supplement the verbal definition of an object with an illustration of it, in motion if so desired, and the additional information that relates it to other work in the passage - these are all developments of the kinds of aids to teaching which good organization and imagination can bring into the classroom and can, good fortune prevailing, on occasion"bring off". The ability to duplicate a good performance at the next presentation is even more rare. The module, too, can malfunction but here the problem is technical and all the student has lost is a segment of time which can be made up at no academic penalty as soon as the system is "up" again with all its pedagogic pennons flying.

It is already obvious that a structure this complete places a new degree of responsibility on the student. Since the machine is more flexible in its hours, patience and direction than the instructor, the students' good faith almost ceases to be a consideration. The same system which records degrees of correctness and completeness also notes the amounts of time spent from the placing of one punctuation mark and the next to the totals spent in each section and the module as a whole. "Class attendance" has never been less of a problem.

As in a lecture situation, the instructor ultimately chooses the degree of proximity to each student. The machine need neither narrow nor extend that gap, nor does it in and of itself separate the learner from the teacher. It has not done so in my experience. What I have appreciated is that when students discuss material with me,the level of our consideration is very high simply because the thoroughness of presentation means that repetitious and obvious questions are already answered and what remain are the interesting areas where no simple solution exists. These are often the meeting points of theory and practice where we talk now from a wider basis of shared experience.

The second advantage in individual discussions is the very complete marks record which the machine provides - a record far beyond the best endeavours of both student and instructor to supply manually. Not only does it keep this record but it analyses it at any degree of statistical function which I am capable of requesting. The results for my field are significant. For the first time we have been able to consider the sequence and duration of how a reader comes to orally stress a given passage - to consider in effect how it comes to have meaning among its units. As far as I know this kind of research has not been done before because the methods of assessment have not been available.

But of greatest use to the student immediately is the clear record of choices, categories and patterns by which any reader derives the meaning of the passage. Errors or deficiencies in the final essay presentation can be seen in the progress across responses which led up to them. Obviously, the positive aspects of this are equally true. Successful patterns lead to successful expression and students can extrapolate and apply the methods on subsequent analyses. The records are cumulative and allow me to compare an individual accurately to a group and to plot long term effects of the way I have expressed parts of the work and to check teaching effectiveness by modifying them. The preparation of the module has permitted me to review my teaching techniques and reconsider what I am doing and how I can consider improving it.

The kinds of problems unique to COMIT are few but large. Technical efficiency is crucial and the complexity of functions within my module made this its major fault. In its present form the synchronization of screen display and sound recording is unreliable; the best slides, where resolution and distinction among close colour patterns is paramount, have deteriorated. In a few circumstances the machine's inability to discriminate among student responses on the screen surface has invalidated performance records and angered users as they saw their carefully derived conclusions applied to completely inappropriate phrases in adjacent lines. Most frustrating are delays in machine response time to student decisions and requests. Not only do these make records of time study useless but, more importantly, they frustrate the user more than all other factors combined. Pedagogic questions of the optimal combinations of visual display, text and audio explanation have been resolved to my satisfaction but experience in this area has been hard-won in terms of time involved.

The solution of how to adapt the module to users with no previous experience with computers, typewriters, sonic pens or programmed learning were tackled and resolved by the project organizers from the outset. I still wince at the phrase "Simple enough for Artsies!" but I realize its importance.

Student response has been mixed. Initial trepidation generally gives way in the second session to a giddy, unwarranted sense of being master of all things electronic. My initial fears of users feeling at sea or of being manipulated by the lesson have been unfounded. I am aware of the optimism that equates novelty with a teaching breakthrough but I have also experienced the pleasure of students genuinely asking for additional material (of which none exists) and of suggesting ways in which this technology could be applied to their other studies. Their frustrations have been almost exclusively with malfunctions of equipment though, as I applied the lesson to more junior students, some felt and demonstrated in their results that the level of the work was beyond them. On the positive side several among the various groups saw the method as the most powerfully persuasive of any they had met in their training. What has clearly emerged is the need now to provide a greater range of related material to see if the technique can be applied as successfully beyond a specific lesson as a sustained method of teaching in its own right.

Because I have been asked repeatedly about it I must comment on the demands on time and resources this kind of preparation places on an instructor. Almost all phases of the programming have been done for me accurately and with despatch by the COMIT group and I am aware of, and thankful for, the blessing. The questions I asked, the progression of teaching and illustration and the responses I incorporated all derive from, and are compatible with, teaching I have in progress and the results I have obtained have been new ways of testing and confirming my ongoing work in the classroom. The extensive and thorough recording and marking have given me both new insights into the ways readers perceive the passage and suggestions for how I might more effectively present the work to a class. On balance then, the preparation has been neither odious nor overwhelming. Major changes in format have been accomplished often by the expedients of clearly marking on the print-out what segments I wished to have removed from the screen and recorded on audio tape or of matching appropriate slide displays to correspond with student requests. Presuming the level of programming support - one supervisor and two students - much of my subsequent development time would remain collateral with that allotted for lesson development. The many kinds of cross-fertilization between module and classroom further increased the value of the project; I believe that would continue to be true in subsequent work.

Within the materials and methods of my discipline this kind of teaching has, to my mind, an unlimited application. I have already indicated that the area I selected for experiment would not seem at first glance to be a logical starting point. It involves a good deal of theory, employs more method than fact, requires subtle distinctions among many levels of language and involves choices in personal taste and judgement. I presume, because the module can be rendered flexible enough in both its presentation of material and its ability to discriminate among answers, that an author would encounter fewer difficulties presenting more established or traditional fare in the history or genres of our subject. Because this module incorporates aspects of different parts of our discipline - linguistics, etymology, structure, social context, to list several - and because it integrates them successfully, I would presume that they could be expanded and successfully developed in other subject matter. As well, the need to develop a body of common devices - the glossary, definitions and applications of critical terms and the like - will decrease as authors discover that they can draw on previously prepared material. So the future uses in my subject area are limited only by our acceptance of the method and our willingness to work in it.

But I wish to conclude my remarks by returning to what I regard as central in our concern in this work - the ways in which the student, the end of our efforts, benefits by its use. It is here, more than in any other feature, that the module's value lies--in the individual's being required to create the answers to questions which form the lesson, of having to be responsible for, not merely listening to, or passively watching, the lesson. The machine is rigid in its demands for answers and in its unremitting record of performances. It permits review in ways an instructor cannot; it is designed to encourage the user to consider and explore relationships in models not available in the classroom; it incorporates opportunities for students to comment on, and to ask larger questions about, the subject and method. But, after all is said and done, it is uncompromising in its insistence that each user meet each of its questions, puzzles or requests for knowledge and structure and it will not proceed on the happy assumption that the person sitting in front of it actually does understand and declines to answer because the question is not of sufficient interest.

At the outset my purposes in COMIT were twofold; I sought a teaching device which made no compromise with the best academic standards of my subject and which involved the student at each stage of the lesson more directly than the conventional lecture method can. It is not a question of belief but rather a matter of fact that modules of this kind meet both conditions. Questions of their role vis a vis an instructor, how much of this kind of instruction is optimal, the demands on academic resources in their implementation, matters of cost and the social and pedagogic research we derive are all, in the long run, peripheral. The project's value lies in its thoroughness and the ability to have students take charge of their own learning; Any module's flexibility, across and within disciplines, depends only on the imagination and skill of the authors and designers who create it. Not only in COMIT, but in other systems already functioning in higher education, the only functioning adverb is not "how" or "whether" but "when."

References:

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[2] P. Beam, "The Design of a Computer-Directed Teaching Module in Analytic Criticism",Third International Conference on Computing in the Humanities, University of Waterloo, August 2-5, 1977.

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Appendix: The passage used in the COMIT English module on Analytic Criticism is shown below:

When the Present has latched its back-gate behind my trembling stay,
And the May month flaps its glad green leaves like wings,
Delicate-filmed as new-spun silk, will the neighbours say,
"He was a man who used to notice such things?"

If it be in the dusk when, like an eyelid's soundless blink,
The evening-hawk comes crossing the shades to alight
Upon the wind-warped upland thorn, a gazer may think,
"To him this must have been a familiar sight."

If I pass during some late night blackness, mothy and warm,
When the hedgehog travels cautiously over the lawn,
One may say, "He worked that such innocent creatures should come
But he could do little for them; and now he is gone." to no harm,

If when hearing that I have been stilled at last, they stand at the door,
Watching the full-starred heavens that winter sees,
Will this thought rise on those who will meet my face no more,
"He was one who had an eye for such mysteries?"

And will any say when my bell of leaving is heard in the gloom,
And a crossing breeze cuts a pause in its outrollings,
Till they rise again, as they were a new bell's boom,
"He hears it not now, but used to notice such things?"

REFLECTIONS ON A COMPUTERIZED MULTI-MEDIA INSTRUCTIONAL TELEVISION MODULE

by

D. K. Erb

Professor

Department of Geography

Abstract: The development of a COMIT module has involved a broad spectrum of experiences. Initially the concepts presented sparked visions of fascinating combinations of computer graphics, slides, tapes, films, student-computer interaction and many other potential "tools" to be utilized in geographical education. The selection of a subject however, lead to a rapid revision of initial concepts. In addition, the methodology of module development soon established the necessity for a much more detailed knowledge of the chosen subject. The steps which had appeared relatively simple and straightforward became complex and time consuming. Finally, the emergence of a reasonably complete module permitted testing to begin and the problem of testing to come to the fore. Attempting to draw conclusions on the basis of inadequate testing results yielded recommendations for the future.

Initial Concept

As originally presented, the objective of Computerized Multi-Media Instructional Television was to combine educational television with computer assisted instruction and to evaluate the educational capability of this marriage.

To a geographer with specializations in the fields of geomorphology and remote sensing, the potential was fascinating. Imagine being able to incorporate in one unified module such diverse but interrelated teaching components as colour movies (video tapes), colour slides, sequential images with appropriate annotation (letters, arrows, dashed lines, etc.), dynamic computer graphics (in which lines could be made to move across the screen, letters could be made to flash on and off to emphasize audio comments, and colours could be used to distinguish the various segments being discussed), a sonic pen (which could be used by the student to indicate his or her selection in response to a visual or spoken query) and audio commentary overall (discussion, explanation, or query). Visions of colour movies showing waves breaking on a beach at normal speed and then in super slow motion, followed by graphics illustrating the way in which water particles moved in a "normal" wave, then in a wave breaking on a beach, the whole backed by the sounds of breaking waves and a discussion of wave dynamics, and followed by a series of questions to evaluate the students' comprehension of the factors and concepts involved, and of an almost infinite number of similar possibilities, were generated. Enthusiasm ran high.

Module Development

Then the crucial question was posed; given the need to test this apparently unlimited potential system, what small segment of a course currently being given should be developed into a COMIT module?

From the many possibilities, a segment which seemed ideally suited to the technique (as discussed above), or a segment which formed a small, important, but difficult to grasp, part of the course, could be selected. Based on numerous factors, but primarily the difficulty experienced by students in understanding the concept and the consequent length of time spent on explaining it, the subject of parallax, as used in remote sensing, was chosen.

Parallax is defined as: "The apparent displacement of the position of a body with respect to a reference point or system, caused by a shift in the point of observation".

Initially, the approach taken in attempting to set up a module was, in essence, to translate the lecture format to the COMIT format. A considerable number of weeks later, weeks which involved pages and pages of writing, innumerable diagrams, and enlightening discussions with the COMIT advisors, a significant factor became evident; the "author" didn't know as much about parallax as he thought he did!

This somewhat less than earth-shaking discovery led to an intensive review of the literature on the subject. This in turn led to another discovery; many other authors of texts and reference works, were unable to explain the concept of parallax clearly and concisely, or in any event, had not bothered to do so in their works!

However, an acceptable explanation was eventually formulated and the problem of developing the module was again attacked.

The first approach involved a spot on the screen, a student, and his or her thumb. The student closed his left eye and held his thumb between his right eye and the screen such that it obscured the spot (Figure 1 a); then,

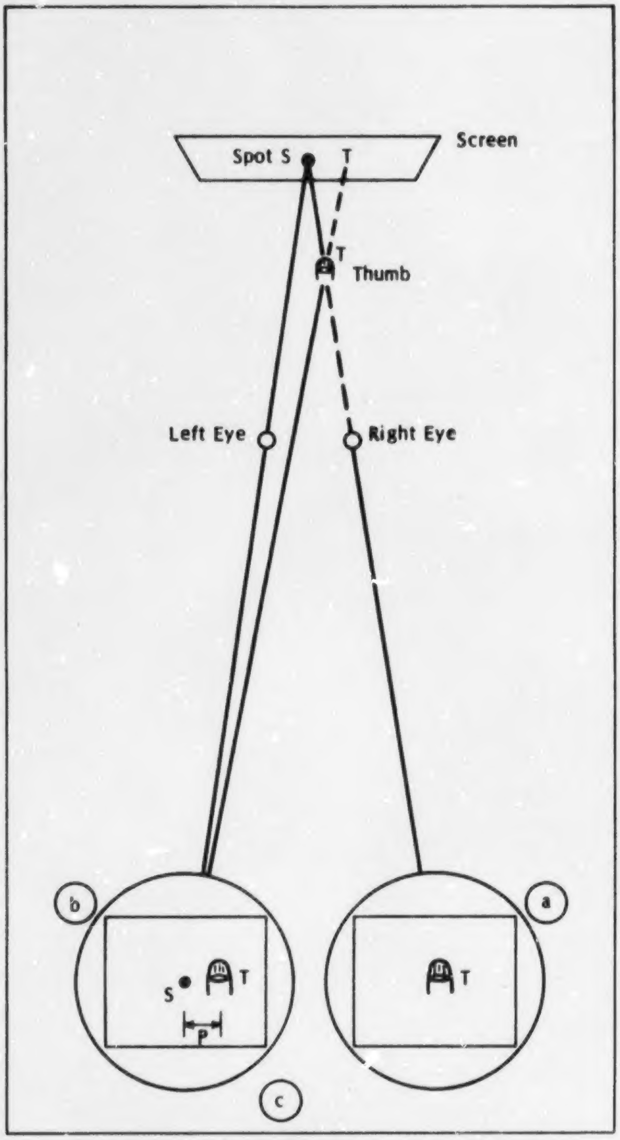

Screen
Spot S
T
T
Thumb
Left Eye
Right Eye
b
S
T
P
a
T
c

Figure 1 – a, b, & c

a. Right Eye View – Thumb, No Spot

b. Left Eye View – Spot, Thumb to the Right

c. S – T in I.b. is Parallax Displacement P maintaining the same position (ie. not moving his head or his thumb), he closed his right eye and opened his left. At this point he could see the spot again and the thumb appeared to have shifted to the right of the spot (Figure 1 b). This apparent shift in the position of the thumb with respect to the reference point on the screen, when viewed from two different points in space (the right eye view and the left eye view), is called parallax displacement (Figure 1 c).

Problems of relating this simple example to the geometry of a sequential pair of air photos led to a number of revisions, and eventually, after a considerable length of time, to a somewhat different example involving a tree, a pole, and a car moving along a highway. This produced a sequential set of images which not only illustrated the apparent displacement of one body with respect to another and, in turn, both with respect to a reference point, but also permitted the utilization of a movie or video tape sequence which related the concept to a common every-day experience (Figures 2 a,b,c).

It was possible to display the geometry of this situation on the screen using slides; and also, using the dynamic computer graphics capability, to illustrate in a sequential format, the relationship between the angle of parallax (Figure 2) and the linear displacement of the features on the image, ie. linear parallax (P).

Throughout this developmental stage, it was necessary to keep in mind the necessity for interaction between the student and the "message" being presented on the terminal screen. A whole series of questions had to be devised (and answers provided) to lead the student to an understanding of the concept being presented. A number of incorrect answers had to be devised as well, (for each question) and a system of feed-back included such that, if a student selected the incorrect answer, he could request a review of the material, or a "hint", in order for him to satisfy the requirements before he proceeded to the next step.

Intermediate phases of the module involved measuring the apparent displacement (parallax) on the screen using scales incorporated in the image (Figure 3) and, in the final phases, the translation of this example to the aerial photograph and the geometry of parallax measurement as a method of determining heights of objects (Figure 4).

However, since this paper is not attempting to explain parallax, but rather to evaluate the COMIT approach to explaining parallax, no further

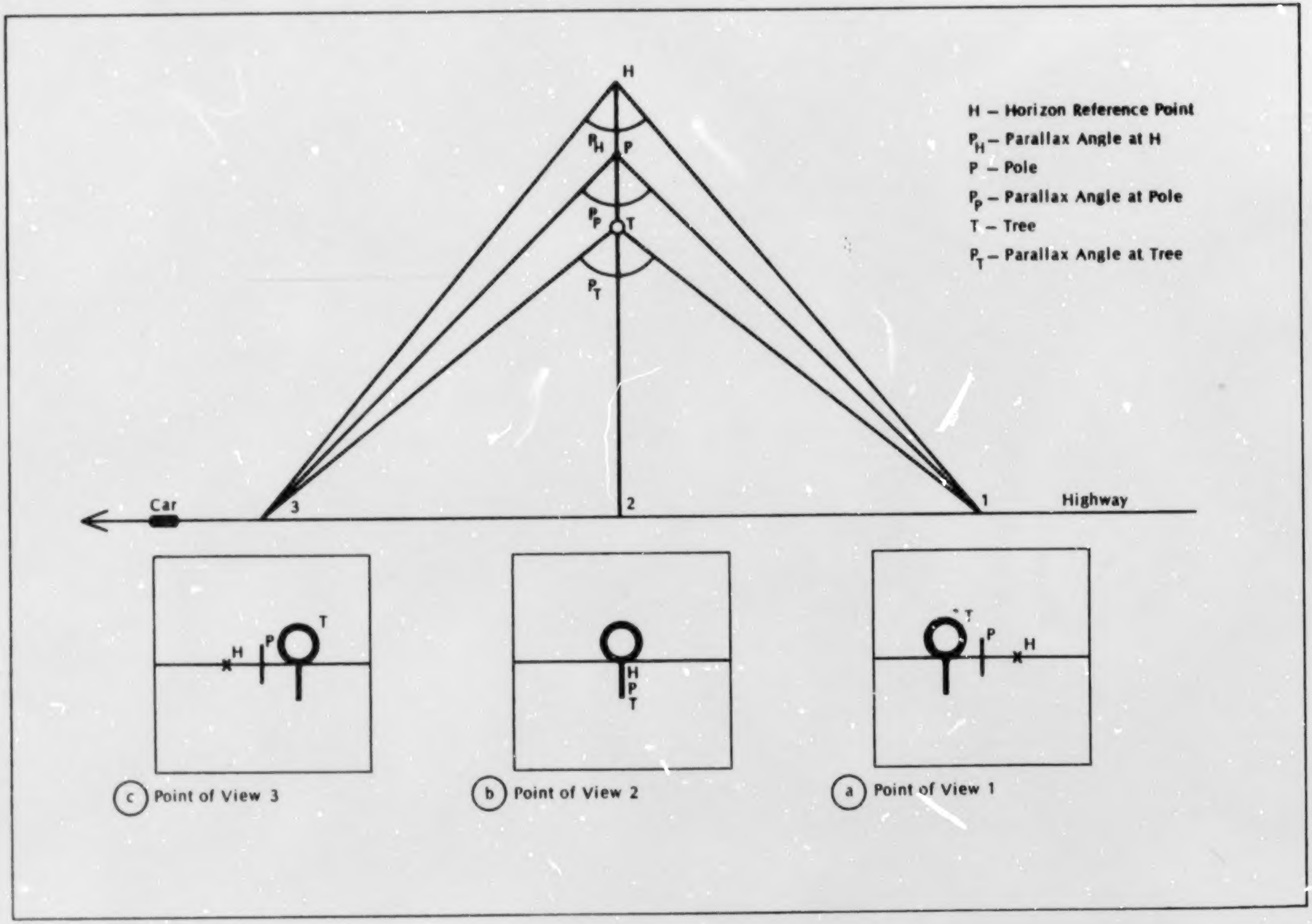
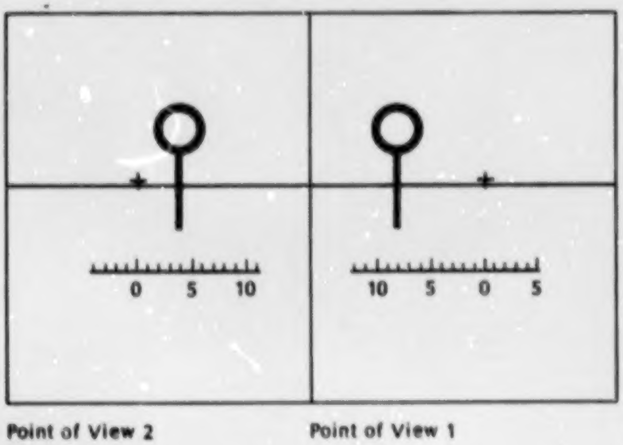

H
H – Horizon Reference Point
P_H – Parallax Angle at H
P – Pole
P_P – Parallax Angle at Pole
T – Tree
P_T – Parallax Angle at Tree
P_H
P
P_P
T
P_T
Car
3
2
1
Highway
H
P
T
H
P
T
T
P
H
c Point of View 3
b Point of View 2
a Point of View 1

Figure 2


+
0
5
10
+
10
5
0
5
Point of View 2
Point of View 1

Total Apparent Movement of Tree with Reference
to + = Linear Parallax of Tree = 8 + 4 = 12 mm
(Measured on Screen)

Figure 3

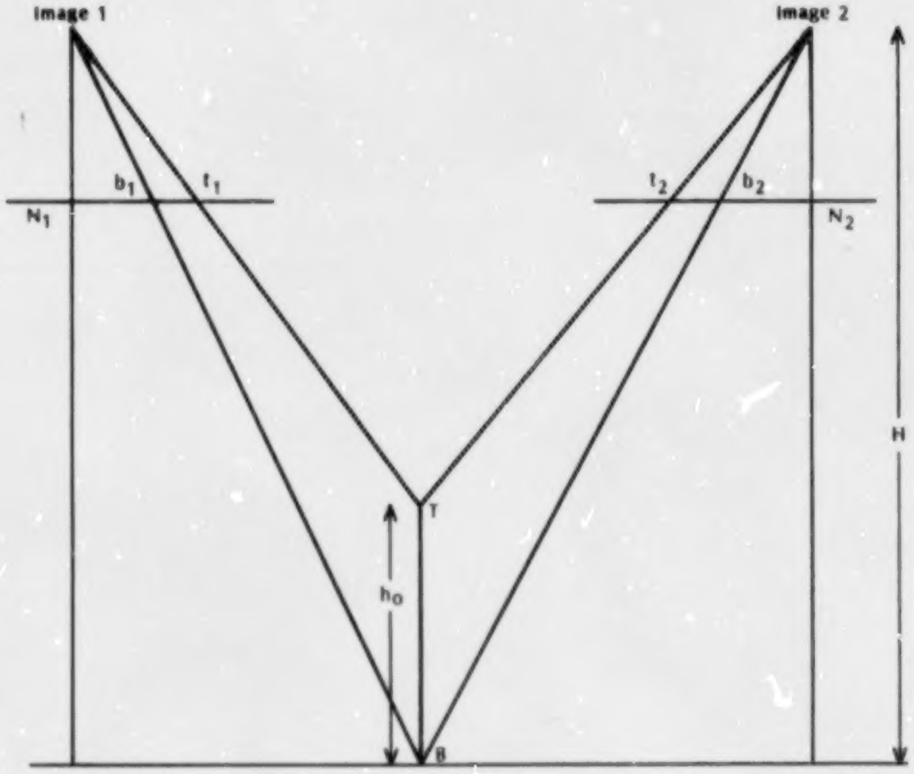


Image 1
Image 2
b_1
t_1
t_2
b_2
N_1
N_2
H
T
h_o
B

Parallax of Top of Pole = $N_1 t_1 + N_2 t_2$

Parallax of Bottom of Pole = $N_1 b_1 + N_2 b_2$ = Absolute Parallax P

Difference in Parallax Between Top and Bottom of Pole = dP

$= (N_1 t_1 + N_2 t_2) - (N_1 b_1 + N_2 b_2)$

$= b_1 t_1 + b_2 t_2$

$$h_o = \frac{H \times dP}{P + dP}$$

h_o=Height of Object
H =Flying Height
P = Absolute Parallax Base of Object
dP=Difference in Parallax

Figure 4

discussion of the actual module steps will be presented.

Having developed the module, the next step was to test it on the members of a class who were responsible for the concepts involved. At this point, one of the major disadvantages became apparent. The author, who at this point at least, should be assumed to know the answers, ran through the completed module on the terminal and determined that the time required was approximately 2½ hours. This was partly due to the fact that it was necessary to use a loose-leaf binder containing all the illustrations and diagrams instead of having them on the screen as previously proposed. This discrepancy or problem was in part the result of the author being on sabbatical during this phase of the programme.

The time required to complete the module when combined with a class of 120, obviously involved a major logistics problem; not only in terms of computer time itself, but also in terms of scheduling access to the limited number of terminals available. As a result, it was decided to use a small volunteer class sample and have them arrange their own scheduling. This proved to be another error. By the time the course had reached a stage involving the use of the concept, it was determined that only a few of the students had actually made appointments and worked through the module. The resulting comments were of minimal assistance in evaluating the system's capability.

This leads to some conclusions with respect to Computerized Multi-Media Instructional Television as a method of teaching a concept.

Conclusions

First, it does not appear to be a system which can be utilized to teach small components of a course, involving large numbers of students. Even assuming a relatively large number of terminals and access to these terminals over extensive periods of time during a normal day, the computer time required and the problems of scheduling the use of the terminals would be excessive.

Second, it is a system which demands a great many hours of input on the part of the author in order to develop a relatively simple module. This assumes an even greater number of hours of input on the part of an assistant, to programme the computer and handle the technical aspects, especially if video tapes, slides, audio tapes and many of the other elements which provide such a fascinating potential, are utilized.

Third, an author, or would-be author, should have or acquire a good working knowledge of computers and computer programming. It is difficult to foresee problems involving question format, answer format, graphic development, video, audio, and slide inclusion, etc., without any background knowledge in the field.

Fourth, unless experienced in COMIT module development, it would be advisable for an author to produce one or two trial modules before attempting a final effort. Familiarization with the problems associated with module development obtained in this trial period would permit the author to save a great deal of time in selecting and planning segments of his course to be presented in module form.

Fifth, the author should be fully familiar with the course segment or concept to be developed as a module. If the author can combine this capability with those discussed in three and four above, development of COMIT modules should not be too difficult.

Sixth, the nature of the subject matter has a great bearing on the use, development and effectiveness of the module format. Very difficult concepts requiring active faculty-student dialogue would not appear to be suitable in this context.

Seventh, in order to evaluate the effectiveness of a module, a statistically valid class sample should be selected, together with a control group subject to the standard method, and the two groups upon completion of the course segment involved should write an identical test. In addition, time expended by the students in the two methods should be taken into consideration. Finally, the opportunity for the one group to re-run the module if details of the concept were not clear, should be taken into account.

Eighth, if an author were to plan on using some, or all, of the various audio/visual capabilities of the system, knowledge of some of the basics of television programming such as story-board preparation, scenario writing, video "tricks", etc., would seem to be advisable.

Future

Most of the potential, which fascinated this author when the programme was first discussed, was not realized in the development of the module discussed here. The capabilities are still there, but it will require a different programme to make effective use of them. In this context, a multiunit module designed to present a complete segment of a course would seem not only feasible, but also desirable. In its initial implementation, it would not have the one-to-one, student/terminal interaction, but would be designed to complement rather than supplement a faculty member, in a classroom situation. However, individual units, making up the larger module, could be utilized, with appropriate visual or audio programmes, to provide the students with a very effective review facility (using a Comit-type terminal).

The above format could be developed for a full course, thus removing the repetitive aspect of a professor's programme and allowing him or her much more time for preparation, discussion, and interaction with the class - regardless of size. The length of each unit would be determined by the proportion of the lecture period assigned for discussion.

Finally, this type of module format could easily be included in off-campus (remote lecture theatre), in-home computer terminal, or conventional television/telephone, educational programmes.

LEARNING FROM COMIT: THE EDUCATIONAL IMPLICATIONS

by

Christopher K. Knapper

Teaching Resource Person

University of Waterloo

Abstract: Experiences with the COMIT System of Computer-Assisted Learning are reviewed in relation to five evaluative criteria: effects on student learning, effects on student attitudes, effects on teachers, institutional effects, and extra-institutional effects. Conclusions are drawn concerning the possible future pedagogical role of computer assisted learning systems.

The impact of the computer on contemporary society has been so great during the past two decades that there are few individuals living in the industrial nations whose daily lives remain untouched by this aspect of modern technology. Education has of course been markedly affected by computers, especially with regard to administration and planning. Paradoxically, however, methods of teaching and learning within the educational system have been remarkably little influenced by the computer in any direct sense -- with the obvious exceptions of the use of computers as tools for numerical computation and as a means of teaching programming skills. This state of affairs is perhaps not as surprising as it may seem if we examine historically the impact on learning of instructional technology -- or indeed the impact of pedagogical innovations in general. On the whole, teaching techniques have been remarkably resistant to change, and it might plausibly be argued that no innovation has had any substantial impact on the way students learn -- at least in the formal education system -- since the invention of the printing press.

COMIT is one of the most sophisticated systems of computer-assisted instruction. As John Moore's introduction to this volume describes, it combines the facilities of a powerful computer with a rich and versatile presentation mode that is capable of supplying moving colour pictures, complex graphics and sound. The student's method of responding is also flexible, permitting communication by sonic pen or keyboard. This is an awesome facility, and it is consequently of immense interest to examine in some detail the attempts that have been made to use the COMIT system and, in particular, to assess the success of the system from an educational and pedagogical standpoint. In this respect the preceding reports from COMIT course developers have great relevance.

Assessment Criteria:

In attempting to evaluate COMIT, the question immediately arises of what yardsticks are to be used to judge the effectiveness of such an instructional system. I propose to use five criteria: Effects on student learning, Effects on student attitudes, Effects on teachers, Institutional effects, and Extra-institutional effects.

(a) *Student Learning*. There will be little disagreement among teachers that a principal aim of instruction is to facilitate student learning. Learning, however, is not a unitary concept, and those responsible for the design of instruction must give careful consideration to the particular type and level of learning it is hoped to achieve. Bloom (1956) in his well-known *Taxonomy of Educational Objectives* [1] lists six types of learning (see Table 1) and it is interesting to note that all six types are represented in the COMIT modules described in the preceding papers.

Table 1. Types of Learning (from B. S. Bloom, *Taxonomy of Educational Objectives*, 1956)

Knowledge	-- of specifics
	-- of ways and means of dealing with specifics
	-- of the universals and abstractions in a field
Comprehension	-- translation
	-- interpretation
	-- extrapolation
Application	-- use of rules, methods, concepts
Analysis	-- of elements
	-- of relationships
	-- of organisational principles
Synthesis	-- communication
	-- planning
	-- derivation of a set of abstract relations
Evaluation	-- internal evidence
	-- external criteria

Of considerable interest here are the ways used by the different modules to achieve different learning ends. These range from drill-and-practice techniques and remedial instruction, as described by Delahey to teach offensive line play in football, to fairly elaborate simulations of real-life situations where students are required to apply the knowledge they have attained, achieve some synthesis, and evaluate the efficacy of theoretical notions in relation to the simulated data. A good example of the latter approach is Thompson's programme to teach survey sampling, which exploits a capacity in which the computer excels (storing detailed information and arranging for its retrieval in a variety of different formats) and which would be virtually impossible to achieve by any other teaching technique that can be used in the classroom, as opposed to the "real world".

It is often, erroneously, assumed that the computer should be used to replicate as far as possible the function of the human teacher. (Indeed it is a common error in technological development to devise a machine that performs inefficiently exactly because it is made to ape human performance -- for example the common idea of a robot that looks, walks, and talks like a human would be an incredibly inefficient use of machinery for most purposes.) Computer-Assisted Instruction (as opposed to Computer-Managed Learning, for example) often tends to start from the basis that the learning material should be presented by the computer and confined to this mode of presentation. However, there is no reason why the computer need play such a direct teaching role. It may for instance be used as a learning aid, much like a dictionary or calculator, and indeed this is what Winter has done in using the machine to display various properties of human gait. The computer is also a convenient testing device (it was used for this purpose in nearly all of the COMIT modules) and a useful means of diagnosing each learner's knowledge and abilities so as to guide students to material uniquely suited to their individual needs.

This ability at efficient diagnosis, and the idea that the computer can cater to individual learning differences in a way that is not possible in the classroom, is a potential advantage of CAL that is frequently put forward by the system's advocates. Unfortunately in practice CAL, in common with previous instructional technologies such as programmed instruction, has a rather disappointing record of achievement. In reality, few modules employ very sophisticated diagnosis of student aptitudes (let alone student learning styles) and most of the branching techniques used for remedial purposes are fairly primitive, even in comparison with what was possible on the teaching machines of 15 years ago. There are good reasons why this potential strength of CAL has as yet gone largely unrealized: the deficiency is probably due largely to the immense effort of time and commitment involved to write and programme material for this purpose. Hence the modules that in principle could cater to a wide variety of individual differences, and which are capable of continual improvement on the basis of a detailed examination of student responses, may remain in a crude and unmodified form indefinitely. Naturally, it is too early to say whether this will be so for the programmes developed in COMIT, although the fact that the system in its present form has been dismantled makes the question somewhat unfair or irrelevant.

If it is accepted that some demonstration of student learning is important evidence of teaching success, then attention turns to the types of evidence that might be useful for this purpose. Evaluation of any teaching intervention may be carried out in terms of a change in knowledge or (in the case of the teaching of a skill) behaviour compared to the abilities demonstrated immediately prior to the start of the teaching. Such "pretest - post-test" comparisons, if they are to be meaningful, should be related to carefully stated learning objectives that can be operationalized in terms of specific behaviour change. (Even then it is often difficult to know whether the change was due to the teaching, to some extraneous factor, or a combination of both.) Sometimes an attempt is made to supplement evidence of such changes on the part of learners by comparative measurements for a group of people to whom the material was presented in some other way (or to whom it was not presented at all). A full discussion of the design and shortcomings of such evaluative strategies is beyond the scope of the present paper. Suffice it to say that several of the contributions to the present collection describe attempts at evaluation that incorporate pre-and post-tests as well as comparisons with other teaching techniques. Some general comments about just what conclusions can be drawn from such studies are made at the end of this paper.

(b) Student Attitudes. A measurement of learners' attitudes to a system of instruction, while less important than evidence of student learning, is of value, not least because favourable attitudes are likely to facilitate learning (or, conversely, unfavourable attitudes are likely to be highly disadvantageous for learning). Nearly all of the preceding papers report on student reactions to their experience with the COMIT system, gathered either by means of a structured questionnaire or from informal interaction with the module author. As is often the case with teaching innovations (indeed with any teaching technique) both positive and negative attitudes are reported. Negative comments relate to the monotony and lack of flexibility of the system: aspects that different authors attempted to deal with by different means, such as humour or the provision of ancillary notes. Another feature of the system frequently mentioned in a negative vein was its impersonality compared to a real, live teacher, and one attempt to combat this feature and add a "human element" to the learning experience is described by Avedon and Stewart.

This brings up the important question of the "man-machine interface" and the related, more general question of motivation in learning. Unfortunately our knowledge of the process by which humans relate to machines in both positive and negative ways, as well as our understanding of why machines are exciting for some individuals and frightening for others, is disappointing to this point, notwithstanding increasing attention by researchers to the question. It is interesting, for example, that most of M^c^Bean's students could spend no more than two or three hours at the COMIT terminal, while we know that students of similar age and intelligence will spend much longer periods passively watching a somewhat similar machine (television) or interacting with machines that seem on the face of it far less challenging (pinball machines, slot machines, and so on).

In terms of positive attitudes to COMIT, many students expressed pleasure at the idea of proceeding at their own pace and being able to review the material presented -- attributes that are not confined to CAL, but are greatly facilitated by such a system. In the case of favourable comments to the general notion of learning via such a system (and there were many such comments) it is important to recognize that there may be a confounding influence caused by the very novelty of the system and the fact that learners were part of a special experiment (the "Hawthorne effect"). On the other hand, some of the negative comments may come from conservative students who are resistant to any new type of learning. Furthermore the greatest area of negative reaction -- which concerned the technical problems with the system -- relates to features of COMIT that could almost certainly be remedied in the future.

(c) Effects on Teachers. The attitudes of authors and instructors to the experience of working with COMIT reflect the same divergence of opinion as do those of the student learners, and range from considerable enthusiasm about the general potential of the system to a measure of disillusionment, with positive attitudes predominating (perhaps not surprisingly in view of the need to justify the great amounts of time and energy expended on preparing the modules). The negative comments were clearly influenced by frustrations with technical aspects of the system (frequent breakdowns and slow response time) and the immense amount of authoring time required.

Of even more interest, however, are the comments by authors about the teaching/learning process itself that have applicability far beyond the COMIT system or computer assisted learning. For example, three of the authors, as a result of working on the preparation of their modules, soon realized that their knowledge of the material and their understanding of the best way to organize the material for efficient learning was far less than they had assumed at the outset, in spite of several years of lecturing on basically the same topics. If this was primarily a self-insight, there were other insights into the learning process itself. For example, four of the authors came to the realization that learning is essentially an active process that requires students to respond constantly and frequently, rather than passively receiving transmitted material, as happens frequently in so much traditional teaching. Authors also commented on another learning principle that is well known to psychologists but frequently ignored in the classroom, the notion that effective learning requires frequent and immediate information to students about how well they are progressing with the learning task. At least one of the authors raised the important issue of social factors in learning, to what extent students benefit from working alone at their own pace as opposed to learning with and from other people. Hence McBean felt that many of his students were able to benefit from being able to work in pairs when reviewing the material in the module.

It is important to realize that these insights about the learning process are not restricted to learning by computer, but are generally applicable. At the same time, it is instructive to see how effectively they were brought home by the experience of working with a new instructional system, such as COMIT, that places new demands on the teacher, especially with regard to the way he or she analyzes, selects, and structures the material to be learned. Even for experienced teachers it appears that involvement with a new medium of instruction leads to a rethinking of principles and techniques previously taken somewhat for granted. To this extent experience with COMIT is of undoubted benefit to those involved in designing and administering the different modules.

(d) Institutional Effects. Over the three year existence of the COMIT project there was a considerable outlay of institutional funds and resources and an even greater investment of time on the part of the project staff and module authors, not to mention the effort and involvement of the many hundreds of student learners. Yet the essential components of the system have now been disbanded with little likelihood that the University of Waterloo -- at least in the short term -- will change its basic methods of teaching. Why is this the case, and why has this been the fate of so many experiments in educational technology in established educational institutions?

Part of the answer lies in the inherent conservatism of academics -- and students -- when it comes to the implementation of new methods of teaching and learning. Additional reasons relate to the basic complement of skills that most faculty bring to the teaching process (few faculty are trained in pedagogy and most learn through the examples of their own teachers), to the considerable costs involved (to cite just one example, the costs of providing and servicing an adequate number of terminals), and to the general reorganization of the university system that would be required in terms of timetabling, classroom arrangements, and so on. Furthermore, at a time when universities are threatened with severe financial stringencies and the very job security of university teachers is challenged, the political climate is probably not conducive to the introduction of a radical change in teaching methods, especially when the arguments for effectiveness are equivocal. Hence in the immediate future innovations like COMIT will probably remain in the domain of experiments to be tried and tested in forward-looking institutions, by faculty who are willing to devote their time and enthusiasm largely for the reward of their own self-satisfaction and personal insights into the learning process.

(e) Extra-Institutional Effects. In his introduction to this collection Moore states that one aim of the COMIT project was to see what implications might result from the experiment for extramural education. He points out that this system seems to have particular promise in that its basic component is an ordinary colour television monitor (though supplemented with a number of sophisticated additions, such as a light pen, keyboard, and so on). It seems probable, however, that any hopes to introduce such a system on a widespread basis are rather premature.

In the first place, there appear to be formidable technical obstacles to the efficient operation of such a system, even when it is used "in-house" on a fairly small scale, and with constant technical assistance available to students using each terminal. Secondly, the authoring time required to produce material is vast, especially when it is borne in mind that the segments represented by the modules described here comprise only a fraction of the material normally presented in the one-term courses of which they form part. Thirdly, it is probable that the outside clientele for such a system is probably considerably more conservative about pedagogical matters than the student body in established institutions of higher education. In this regard the British Open University is an interesting case in point. Although this is a remarkable social innovation, from a technological and pedagogical point of view it is fairly orthodox, relying on the traditional mainstays of further education -- correspondence courses, personal tutors, textbooks (albeit extremely well organized ones) and traditional lectures during the compulsory periods in residence. The television component of the Open University is just that -- good television programming, involving none of the interactive element that is a principal feature of COMIT and CAL in general.

COMIT and the Future Role of Computers in Education:

A number of the experiments with COMIT described in previous papers have attempted to compare the system with other teaching methods. In the last analysis, however, such an approach is probably unproductive. Rather, we should try to analyze which media of instruction, including the human teacher, are most suited for particular pedagogical ends and for particular individual learners. This is a research question of great importance, about which very little is known as yet.

In the COMIT system the computer, it could be argued, is best seen not as a teacher, but as a "super-coordinator" of instruction -- potentially better than the human teacher at this task, though whether acceptable in this role by the human learner is something that has yet to be determined. Certainly COMIT is far from cheap as a coordinating system, even though it is far less expensive in this role than when it is used as a direct teaching device. It must then be asked if it is worth this cost, or whether we shall continue to use our existing systems, largely human, or some alternative non-human, non-computerized system, such as written modules that are capable of guiding learners to a variety of existing resources.

If we accept the computer as a useful coordinator of instructional resources, then we must seriously question the notion that all the material involved has to be presented directly on the computer itself. The system will depend ultimately, I would suggest, not solely on its efficiency, but also on its flexibility. This is the future challenge of computers in education, and an issue for which the COMIT experiment has provided invaluable empirical data.

Reference:

[1] B. S. Bloom, Taxonomy of Educational Objectives: Handbook I. Cognitive Domain, McKay, New York, 1956.

COMIT SYMPOSIUM

SCHEDULE FOR PARTICIPANTS

A SYMPOSIUM ON COMIT

Presented under the auspices of the
Computers in Education Committee and the
Teaching Resource Person

Place: MC 5158
Date: Thurs, 6 April, 78
Time: 1:00 p.m.

FINAL PROGRAMME

Call to Order 1:05 p.m.
G.C. Andrews, Chairman, Computers in Education Committee

Introductory Remarks 1:10 p.m.
T.A. Brzustowski, Vice-President (Academic)

A Brief Summary of the COMIT Project 1:15 p.m.
J.B. Moore, COMIT Project Director

Some COMIT Highlights 1:35 p.m.
E. Elkeer, IBM, Project Coordinator

Representative Papers by COMIT Participants:

1. COMIT: The Leisure Experience 1:50 p.m.
   E.M. Avedon and T.O. Stewart, Dep't of Recreation
2. Armchair Survey Sampling: An Aid in Teaching Survey Design 2:10 p.m.
   M.E. Thompson, Dep't of Statistics
3. Student Response to Computer-Aided Teaching 2:25 p.m.
   E.A. McBean, Dep't of Civil Engineering

Coffee ——— 2:40 - 3:00 p.m.

4. COMIT and Offensive Line Play in Football 3:00 p.m.
   W. Delahey, Dep't of Athletics
5. COMIT and Hockey Systems 3:15 p.m.
   R.C. McKillop, Dep't of Athletics
6. A COMIT English Module 3:30 p.m.
   P.D. Beam, Dep't of English
7. Computer-Assisted Instruction in Organic Synthesis 3:45 p.m.
   V.A. Snieckus, Dep't of Chemistry

General Discussion and Summary 4:00 p.m.- 4:30 p.m.
Moderator: C.K. Knapper, Teaching Resource Person

RECEPTION: Following the Symposium, there will be a reception in the Faculty Club for all persons attending the Symposium. Wine and Cheese will be served. 4:45 - 6:30 pm (approx.)

Note: All persons wishing to attend the Symposium must contact Heather Baker (Ext. 3132) to reserve a place